Board Summary Report June 2015

Regenstrief Center for Healthcare Engineering

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National Impact
Infusion Pump Informatics Community of Practice and Beyond

Shared research and analysis among hospital project partners

123 Healthcare Providers 4 Healthcare Vendors

National Coalition for Infusion Therapy Safety

Purdue University Discovery Park
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The Regenstrief Center for Healthcare Engineering

Purdue Commitment

As the Regenstrief Center for Healthcare Engineering (RCHE) enters a new phase at Purdue University, our goal is to establish a clear vision and strategy for achieving national prominence for RCHE through its research programs and their impact. Purdue is strongly committed to the success of RCHE and is determined to provide the necessary leadership, resources, and planning to insure RCHE achieves its vision, fulfills its mission and becomes a source of pride for the Regenstrief Foundation.

Leadership – President Daniels, realizing that more needed to be done to fulfill Purdue’s commitment to the Regenstrief Foundation and instill Foundation confidence and satisfaction in RCHE, charged one of his most valued and accomplished administrators, Executive Vice President for Research and Partnerships, Suresh Garimella with the responsibility of visibly and swiftly improving RCHE’s focus and impact. Dr. Garimella announced a national search for a new director in April 2015 and appointed Marietta Harrison as Interim Director of RCHE. Dr. Harrison has many years of administrative leadership experience with large and successful interdisciplinary research centers at Purdue and has the respect and enthusiastic cooperation of RCHE faculty and staff, as well as campus-wide administrators and faculty who are anxious to contribute to RCHE’s future success.

Resources – Purdue is sincerely committed to significantly and rapidly growing faculty interest and eager participation in defining and leading RCHE programs as we move forward. We will fulfill our pledge to hire at minimum five new RCHE faculty and a commitment for five faculty lines has been received from the Dean of Engineering. We are equally committed to establishing a cohesive identity for RCHE faculty, staff and students and will obligate the needed additional space in Mann Hall in Discovery Park to facilitate such an identity and co-working culture.
The Way Forward – The search committee for the new director has been appointed and is chaired by George Wodicka, Head of the Weldon School of Biomedical Engineering. In addition to Dr. Wodicka, engineering is represented by faculty from the schools of chemical and industrial engineering. A complete list of the search committee members is provided in Appendix G. The goal is to have a new director identified by the middle or end of the 2015 fall semester. In the meantime, we will actively pursue two parallel paths to launch RCHE into the next phase of its evolution. First, we will build on the clear success of the Infusion Pump Informatics (IPI) “Community of Care” system and substantially increase the capacity and capabilities of the RCHE informatics HUB, CatalyzeCare, to support the creation of a new entity, the Regenstrief National Center for Medical Device Informatics. Second, we will begin a campus-wide dialog “building on RCHE’s strengths and defining new directions” through a series of “RCHE Idea Forums” that will take place over the summer. The Krannert School of Management, under the leadership of newly appointed Dean David Hummels has convened a summer brown bag series on “Healthcare” in an effort to identify and coalesce management faculty interested in defining and driving new research programs in RCHE. There is palpable excitement as the campus anticipates new opportunities to boost the “healthcare engineering” enterprise at Purdue.
How RCHE defines healthcare engineering

The definition of Healthcare Engineering is in many ways in the “eyes of the beholder.” RCHE approaches Healthcare Engineering as a “systems engineering” problem with a focus on healthcare delivery. There is no shortage of national opinions on what is wrong with the current US healthcare system as well as on strategies for how to fix it. RCHE aims to earn a leading voice in the national conversation through the impact of its research. RCHE sees its mission as creating and orchestrating the healthcare engineering enterprise at Purdue to influence the delivery of care. Purdue engineering programs enjoy national as well as international prominence. Engineering needs to be the foundation on which RCHE rests for that is
where Purdue and the Regenstrief Foundation can make unique and highly valued contributions. As with all grand challenges, lasting and impactful solutions will not come from a single discipline, and that is why the major engineering gear driving RCHE’s healthcare engineering system is meshed with other strong disciplines at Purdue. RCHE’s greatest asset is its faculty, and as those faculty generate ideas and projects they will have the RCHE-supported network and resources to expand into the interdisciplinary space that is necessary to achieve real influence. The gears are all currently machined, the challenge is to get them to perfectly mesh and generate the power to drive the strong RCHE programs that will result. RCHE views Healthcare Engineering as the collection and analysis of data that results in the generation of new tools and devices that will drive improvements in healthcare delivery resulting in improved patient outcomes and increased patient safety.
**What RCHE will be known for**

**Vision:** to become a national resource for the improvement of healthcare delivery

**Mission:** to harness the intellectual strengths of current and future Purdue faculty to collaboratively drive the interdisciplinary healthcare engineering enterprise at Purdue University

RCHE currently is recognized for its national leadership in infusion pump alert data analyses. The number of hospitals contributing data to and generating reports from RCHE’s CatalyzeCare HUB has risen from 10 (located only in Indiana) in 2010 to 123 (located nationally) as of May 2015.

“In June 2013, the Joint Commission approved new National Patient Safety Goal NPSG.06.01.01 on clinical alarm safety for hospitals and critical access hospitals. In Phase I (beginning January 2014) hospitals will be required to establish alarms as an organizational priority and identify the most important alarms to manage based on their own internal situations. By 2016 hospitals will be expected to develop and implement specific components of policies and procedures. Education of those in the organization about the alarm system management will also be required.” Joint Commission Perspectives®, July 2013, Volume 33, Issue 7
Realizing that alarm safety was an emerging concern among hospital administrators and national regulatory organizations, RCHE focused attention on this escalating patient safety issue in 2010 before it reached the level of high national awareness. Using Purdue HUB technology (developed through a $38 million investment from the National Science Foundation), RCHE established a HIPAA-aligned HUB (www.CatalyzeCare.org) as a portal to support an internet accessible, national “Drug Limit Alert” database. Currently (May 2015) 123 hospitals across the nation deposit alert data from smart pumps delivering IV drugs to patients into CatalyzeCare and generate comparative reports summarizing their hospital’s alert data relative to other hospitals in the database. Most importantly, the reports are used in real-time to identify candidate drugs for in-house changes to the “drug limit libraries” that hospital pharmacists generate to program smart pumps delivering drugs. This resource has grown dramatically since its inception and during the last four months alone growth has averaged eight new hospitals per month. Collectively, this “Community of Practice” is known as the RCHE Infusion Pump Informatics (IPI) System. RCHE sponsors three national conferences a year, one in-person and two “virtual,” for this IPI community. The in-person conference is held at various venues throughout the Midwest and is attended by pharmacists, nurses and representatives of various national organizations who have an interest in infusion pump safety. Given the Joint Commission’s edict on alarm management, it is not surprising that the Association for the Advancement of Medical Instrumentation (AAMI), the American Society of Health-System Pharmacists (ASHP), and the Institute for Safe Medication Practices (ISMP) all have contacted RCHE to explore: 1) significantly expanding IPI’s capabilities, and 2) establishing a national standard for infusion medication.

AAMI, in particular, is eager for RCHE to expand CatalyzeCare to support not only all smart pump alert data (currently CatalyzeCare only houses drug alert data, which represents approximately 10 percent of all alert data), but to significantly increase its capabilities to support and analyze physiologic sensing data from various hospital-based medical devices. RCHE is tremendously excited by this opportunity and plans are rapidly developing with the Purdue HUB development team to begin this expansion process. Our vision is to create and launch the Regenstrief National Center for Medical Device Informatics within RCHE by September 2015 and have it fully operational by the end of 2016.

The IPI project and its planned expansion is the foundational example of “what RCHE will be known for.” IPI has already spawned novel research directions at Purdue resulting in the “Best Paper Award” from the Academy of Management for Dr. Benjamin Dunford’s “The Organization Made Us Do It:
Demanding Formalization and Workaround Attributions,” an organizational theory-based analysis of nurse workarounds to “smart pump alert fatigue.” This is an excellent example of the potential of the RCHE healthcare engineering enterprise, and much more is expected to follow with the acquisition of substantially more and larger annotated datasets (including patient conditions and outcomes). Not only will RCHE’s vendor partnerships (currently limited to smart pump manufacturers) greatly expand, but we envision creating new partner opportunities for providers of healthcare information technologies, such as the Cerner Corporation with whom we are in current discussions. All this will lead to a stronger, more comprehensive and powerful research resource for the center and its faculty.

The planned extensive expansion of CatalyzeCare will increase the capacity for data storage and analysis by at least 1000 fold and will provide a coveted resource for RCHE faculty and staff as well as a catalyst for national standardization of medical instrumentation data. In 2015, RCHE became one of only 84 Patient Safety Organization designees and one of only two in Indiana, initially allowing for the confidential deposition of additional IPI-related data into CatalyzeCare.
How RCHE will get there: the roadmap

The process for selecting a new director for RCHE began with the first meeting of the search committee on May 19, 2015. The plan is to formally advertise the position in early June and to immediately begin to generate a list of potential candidates from the individual networks of the search committee members with the goal of generating a rich and diverse pool of outstanding candidates. The committee is ably assisted by an executive recruiter from Purdue’s Talent Acquisition Team, which provides assistance for mission-critical positions at the university. On-campus interviews are expected to begin in August with a new director on board by the middle to end of the fall semester.

RCHE will continue to move forward rapidly on two parallel fronts as the search process progresses. The first is the establishment of the Regenstrief National Center for Medical Device Informatics and the accompanying major expansion of the HUB capabilities of CatalyzeCare to support the national medical device data that will be the foundation of the Center. The second is the convening of campus-wide “RCHE Idea Forums” to engage faculty in identifying and leading major research programs within RCHE.

The substantial extension of the capabilities of CatalyzeCare was enthusiastically embraced by Purdue’s Vice President for Information Technology & Chief Information Officer who has responsibility for the HUB development team. He is currently in the process of identifying a senior member of his staff to oversee and drive the technology development that will be needed to house not only a tenfold increase in smart pump alert data, but the addition of drug interaction alert data, other medical device alert data as well as
physiological sensing data from monitors and ventilators. The latter will demand new technology design as data from monitors and ventilators are quite complex compared with alert data from smart pumps and in this regard we envision engaging Purdue engineers and computer scientists with our HUB development team to design and develop the needed capabilities.

Serious discussions are ongoing between RCHE and the Departments of Biomedical Engineering and Computer Science regarding the establishment of a Medical Cyber-physical System Laboratory to support the Regenstrief National Center for Medical Device Informatics. The vision is to establish both physical and virtual spaces where next generation medical alert and monitoring devices will be designed and integrated with wireless sensor networks and other cyber components to form advanced analytical systems for healthcare applications. A key component of this vision is the generation of a business model where a pre-competitive space is established to attract vendors who wish to support next generation basic technology development in the medical device arena. The generation of this model will fall under the responsibilities of the Center’s new External Advisory Council discussed below.

A critical element of success for the proposed Regenstrief National Center for Medical Device Informatics will be the formation of an External Advisory Council to guide the Center through its initial and long-term planning process, a major focus of which will be on the development of a long-term sustainability model. The External Advisory Council’s composition is envisioned to include representatives from national organizations that have relationships with RCHE (AAMI, ASHP, ISMP), representatives from relevant vendors (device manufacturers, healthcare informatics companies), and representatives from key constituents (healthcare systems administrators). This council will play a pivotal role in the Center’s development and ultimate success and we will engage the necessary Purdue assets (from the President to critical Deans) to recruit appropriate individuals of high national stature.

Campus-wide “RCHE Idea Forums” are planned for the summer to engage faculty in lively and thought-stretching discussions to seek areas of critical mass interest and seed ideas to funnel into the RCHE healthcare engineering machine. The first forum will center on the vision for the Regenstrief National Center for Medical Device Informatics, while subsequent forums will be more open ended. The faculty leadership teams that arise from these forums will form the nexus of RCHE’s planned Internal Advisory Committee. The “RCHE Ideas Forum” resulted from many intellectually stimulating and uplifting meetings Dr. Harrison held with various department heads, Center leaders and individual faculty regarding RCHE’s future.
There was no shortage of ideas, excitement and support for this new phase in RCHE’s evolution. The Krannert School of Management, the School of Biomedical Engineering, and the Department of Statistics in particular are enthusiastic to become more deeply involved with RCHE and contribute to its future successes. All are represented on the RCHE Director Search Committee and are dedicated to finding a new director who will lead RCHE’s research to outcomes with high national impact.
Appendices
Appendix A

Systems Impact
DISCOVERY PARK
Regenstrief Center for Healthcare Engineering

MISSION
The Regenstrief Center for Healthcare Engineering (RCHE) forges enabling partnerships to drive research for improving healthcare delivery systems by applying the principles of engineering, management and science.

FUNDING
The Regenstrief Center receives funding from the Regenstrief Foundation. Research projects also are supported through grants from agencies including the Agency for Healthcare Research and Quality (AHRQ), the National Institutes of Health (NIH), and the National Science Foundation (NSF).

PARTNERS
Center researchers come from nearly all academic colleges at Purdue University. RCHE’s research and dissemination partners include several healthcare systems, commercial vendors and professional organizations — AHRQ, the Association for the Advancement of Medical Instrumentation (AAMI), and the AAMI Foundation’s National Coalition for Infusion Therapy Safety. In 2015, Intermountain Healthcare became the most recent healthcare system joining others including Ascension Health, the Mayo Clinic, Aurora Health Care, IU Health, and Eskenazi Health.

National Impact
Infusion Pump Informatics Community of Practice and Beyond

The Infusion Pump Informatics (IPI) project includes four infusion pump vendors (Baxter, B. Braun, CareFusion, and Hospira), and over 81 hospitals project partners.
**Featured Impacts**

**NATIONAL IMPACT**

**Veterans Engineering Resource Centers (VERCs)**
- The RCHIE led multi-university Veterans Engineering effort resulted in a $20 million investment by the Veterans Administration (VA) to create four regional Veterans Engineering Resource Centers (VERCs). The Centers were designed to facilitate innovative solutions to address healthcare delivery challenges identified by national, regional and facility VA leadership through an integration of industrial, management and systems engineering approaches.

**CatalyzeCare: Essential Infrastructure**
- CatalyzeCare (www.CatalyzeCare.org) is RCHIE’s secure (HIPAA-aligned), internet-accessible healthcare delivery research hub. The major user group leveraging CatalyzeCare is the Infusion Pump Informatics community of practice. Pharmacists from 81 member hospitals nationwide generate hospital-specific and hospital-comparative reports (26,000 to date) from the analyses performed on CatalyzeCare using members’ infusion pump drug limit alert data. CatalyzeCare currently houses over 18.1 million alert data points. This infrastructure is the enabling tool for the planned expansion to include alert data generated by physiological monitors, ventilators, and patient-controlled analgesia (PCA) devices. In 2015 RCHIE became one of only 94 National Patient Safety Organization designees and one of only two in Indiana, expanding national visibility as well as the data sources available to RCHIE researchers. Other RCHIE groups utilizing CatalyzeCare include the Health Systems Engineering Alliance, a consortium of 27 universities from the US, Canada, Mexico and the Midwest, focused on the quality and productivity challenges facing healthcare delivery systems.

**STATE IMPACT**

**Medicaid Patients with Dementia**
- Studies focused on the complexity of care of Medicaid patients with dementia resulted in efforts to assess the prognostic significance of insufficient ADL (activities of daily living) help on health outcomes. Findings that patients remaining in their homes with assistance were significantly less costly prompted Indiana Medicaid to review their policies for funding ADL assistance. **Academic impacts:** 8 published papers in refereed journals, 4 presentations at professional conferences, NIH, Alzheimer’s Association funding.

**ACADEMIC IMPACT**

**Scheduling in Ambulatory Care Settings**
- Focused on multiple dimensions of patient scheduling, algorithms were developed to balance lengthy wait times for appointment scheduling with the practice of overbooking appointments based on projected no-show rates. These algorithms improved patient access and clinic efficiency. The algorithms were delivered to GE Centricity HIS who provides the scheduling systems for the Federally Qualified Health Centers serving as pilot sites for this study. **Academic impacts:** 14 published papers in refereed journals, 2 book chapters and 12 presentations at professional meetings, NSF funding.

**Poverty and Health Inequities**
- Focused on patient and physician communications and community-based health promotions in population segments that demonstrate disparate healthcare utilization and outcomes; studies identified strategies for improving life style choices that resulted in reduced risk for heart disease. The successful health communication techniques were distributed nationally (AHRQ) and regionally (Indiana Minority Health Coalition). Training programs to conduct health assessments and develop community programs to promote effective risk and management activities were developed and implemented. **Academic impacts:** 10 published papers in refereed journals, 2 book chapters and 1 book, NIH, AHRQ funding.
Evidence-Based Communities of Practice

**CatalyzeCare.org: An enabler to national communities of practice – Infusion Pump Informatics System**

The Regenstrief Center for Healthcare Engineering (RCHE) is using a community of practice approach, where focused groups of healthcare providers, vendors, researchers and others share knowledge and best practices, to improve healthcare delivery safety, efficacy, and efficiency.

**Background**

Communities of practice are groups of people who share a concern, a set of problems, or a passion about a topic, and who deepen their knowledge and expertise in this area by interacting on an ongoing basis.\(^1\) A community of practice has three fundamental elements: a domain of knowledge, which defines a set of issues; a community of people who care about the domain; and the shared practice that they are developing to be effective in their domain.\(^2\)

RHCE builds on this concept by adding a decision support tool as a fourth requirement. Members of the community provide data to the decision support tool and, using the reports and analytics capabilities, can examine their own and others’ data. The resulting organizational structure is referred to as an evidence-based community of practice.

To assist communities of practice, RCHE launched CatalyzeCare in 2009. CatalyzeCare is a web-based hub for patients, providers, and researchers interested in improving healthcare delivery to interact online and collaborate on projects. Its secure environment allows geographically disperse research groups to co-develop concepts and share results.

**IPI**

The first evidence-based community of practice formed by RCHE was Infusion Pump Informatics (IPI) in 2008. The IPI community was formed at the request of the Indianapolis Coalition for Patient Safety in response to a dosing error at one of their member hospitals. The vision of the IPI community is, “To be a vibrant, resourceful and collaborative community that advances and promotes infusion pump medication administration in the interest of patient safety and quality.” The IPI community is composed of a mixture of researchers and healthcare delivery providers, primarily pharmacists and nurses, representing more than 65 hospitals. The IPI community shares practice knowledge by posting documents and discussions on CatalyzeCare and by holding a minimum of 3 conferences per year. As an example of knowledge sharing, hospitals make their drug dosing libraries available to other hospitals for review and comparison. Additionally, IPI community members share their infusion pump alert data. These data are viewed via an RCHE developed application providing hospital members the ability to analyze their own alert data and see how results compare to other IPI member hospitals.

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\(^{1}\) *Cultivating Communities of Practice: A Guide to Managing Knowledge. E. Wenger, R. McDermott, W. M. Snyder.*

\(^{2}\) ibid
Today

The IPI community is alive and well as alarm fatigue continues to be a problem for nurses in the clinical environment. Alarm hazards were identified as the number 1 hazard for 2014 by the ECRI institute. New members are being added on a regular basis. Intermountain Healthcare of Utah was the latest member hospital to be added. Support for a third pump vendor, Baxter, was added in April 2015. The Spring 2015 IPI Conference was held in April at the University of Iowa and over 30 clinicians and researchers attended to view presentations and exchange knowledge. The IPI community is recognized nationally as a leader in infusion pump safety and is actively involved in national projects like the National Coalition for Infusion Therapy Safety that gets support, in addition to RCHE, from the Joint Commission, the American Association of Critical-Care Nurses (AACN), the National Patient Safety Foundation (NPSF), and others.

The value of an evidence-based community of practice approach has been recognized by the Agency for Healthcare Quality and Research (AHRQ) with the listing of Purdue as a Patient Safety Organization allowing the knowledge from the IPI community to be applied and disseminated nationally.

Future

RCHE will continue to use evidence-based communities of practice as a way to positively impact the safety and quality of healthcare delivery as well. Future plans including 1) expanding the IPI community of practice to capture all infusion pump alerts, not just those generated from the drug limit library, 2) linking pump data to patient data to better measure impact, and 3) build a drug limit library comparison tool allowing clinicians to find and compare limits more easily and quickly.

There are also plans to expand the evidence-based community of practice approach to other domains. RCHE is actively working to build new communities focused around other medical devices including physiological monitors, ventilators, and patient-controlled analgesia (PSA).

These new communities will provide a fertile ground for Purdue researcher allowing research focused on specific medical devices, but also research on communities of practices themselves.
Appendix B

National Recognition
Patient Safety Organization

The Patient Safety and Quality Improvement Act of 2015 was developed and enacted in response to the Institute of Medicine report, “To Err Is Human,” which generated national concern with the number of preventable medical errors that were occurring. By providing privilege and confidentiality protections to hospitals working with patient-safety organizations (PSOs), the act was intended to promote shared learning to enhance quality and safety nationally. The Agency for Healthcare Research and Quality (AHRQ) is responsible for the regulation of PSOs.

Need

The Regenstrief Center for Healthcare Engineering (RCHE) approached AHRQ with the idea of becoming a PSO, using the Infusion Pump Informatics (IPI) evidence-based community of practice as a source for knowledge and best practices to improve the quality and safety of infusion-pump administration. AHRQ supported the unique PSO model and encouraged RCHE to apply for listing as a PSO.

Objective

RCHE sought designation as a PSO to gain several beneficial strategies.

Approach

RCHE submitted an application and the Regenstrief Center for Healthcare Engineering at Purdue University Patient Safety Organization (RCHE Purdue PSO) was officially listed as a PSO on February 19, 2015. There are 84 total PSOs listed on the AHRQ PSO site, and RCHE Purdue PSO is one of two in Indiana (See http://www.pso.ahrq.gov/listed).

Potential Impact

With its new designation, the RCHE Purdue PSO benefited in the following ways:

- To be invited and participate in AHRQ’s development of national strategies to improve patient safety and associated research strategies.
- Demonstrate the impact of the infusion-pump informatics system and associated research for the Regenstrief Foundation.
- Provide a means of receiving protected health information and furthering Purdue research, consistent with PSO regulations.
- Create visibility with AHRQ as an innovator in patient-safety research and improvement. AHRQ is a targeted national funding source for RCHE research.

RCHE Purdue PSO will allow healthcare providers to voluntarily report information on patient-safety events under legal protection and to use this information to develop patient-safety interventions and
solutions in IV medication administration. We believe this is an excellent example of using Purdue research to provide value to our extended community.

**Partners**

Dan Degnan, Purdue Center for Medication Safety Advancement, College of Pharmacy, Purdue University

**Researchers**

Richard Zink, Regenstrief Center for Healthcare Engineering, Purdue University

**Current Status**

Current activities include attending the 7th Annual PSO meeting in April and executing PSO contracts between hospital providers and RCHE.
NEWS RELEASE

April 24, 2015

Federal agency designates Regenstrief Center for Healthcare Engineering as Patient Safety Organization

WEST LAFAYETTE, Ind. - A Purdue research center funded by the Regenstrief Foundation to help make the nation's healthcare system safer and more cost efficient has been designated as a Patient Safety Organization (PSO) by the U.S. Department of Health and Human Services.

The Purdue Patient Safety Organization, led by the Regenstrief Center for Healthcare Engineering, will be one of only two Indiana-based PSOs, serving as an independent source for collecting and analyzing data to better understand the causes of medical errors that lead to adverse health-care events in patients.

"The Regenstrief Purdue PSO will allow healthcare providers to voluntarily report information on patient safety events under legal protection so this information can be used to develop patient safety interventions and solutions in IV medication administration," said Purdue President Mitch Daniels. "We believe this is an excellent example of using Purdue research to provide value to our extended community."

The RCHE Patient Safety Organization is one of the several RCHE research projects that have benefited from Purdue's strategic collaboration with the Regenstrief Foundation. The Indianapolis-based foundation is contributing $10 million through 2018 for RCHE's research efforts to apply engineering, management and science principles to improve the U.S. healthcare system.

RCHE's research and dissemination partners include 13 provider and professional organizations, and the Mayo Clinic became a partner in 2010, joining others such as the American College of Physicians, Ascension Health and Community Health Network. PSOs, which are administered by the Agency for Healthcare Research and Quality (AHRQ), were launched to implement the Patient Safety and Quality Improvement Act of 2005, enacted by Congress in response to national concern over the number of preventable medical errors occurring that adversely affect patients.

The federal act also created the Patient Safety Rule, which established the framework by which hospitals, doctors and other health providers can voluntarily report information to PSOs, on a privileged and confidential basis, for the aggregation and analysis of patient safety events.

... more ...
Communications with PSOs are protected to allay privacy concerns about increased risk of liability because of collection and analysis of patient safety data.

"Thanks to efforts to support research and advance the mission of PSOs, our nation saw 1.3 million fewer patients experience adverse drug events, falls, infections and other forms of harm in hospitals, 50,000 lives saved and $12 billion in health spending avoided for a three-year period ending in 2013," said Regenstrief director emeritus Steve Witz, Purdue's St. Vincent Health Chair of Healthcare Engineering.

"The Regenstrief Center's designation as a federal Patient Safety Organization will help us deepen our collaboration with healthcare providers in Indiana and across the region and nation to help save lives."

The AHRQ, which is part of HHS, lists 83 PSOs in 30 states. The other Indiana-based PSO is QAIStys Inc. in Anderson. The AHRQ has published a brochure, Choosing a Patient Safety Organization, to help providers select a PSO appropriate to their needs.

Richard Zink, manager of Catalyze Care development and implementation efforts for RCHE, will lead the RCHE Purdue PSO. Its designation as a federal PSO took effect on Feb. 9.

RCHE helped launch the Indiana Patient Safety Center in 2007 and has been working with major Midwestern hospitals through its Catalyze Care project to establish safety standards for infusion pumps, which have become commonplace for administering drugs to patients.

The Purdue center also has partnered with hospitals in Indiana, Iowa, Illinois, Nebraska, Wisconsin and other states to launch the Infusion Pump Informatics Community at Purdue. Through a Web-based tool, users can easily share analysis, data reporting and best practices for what are known as "smart pumps."

Located in Discovery Park, Purdue's hub for interdisciplinary research, RCHE also was a founding member of the Healthcare Systems Engineering Alliance, a national professional organization promoting excellence in research and education in healthcare systems engineering.

The Indianapolis-based Regenstrief Foundation provided the initial $3 million to launch Purdue's Regenstrief Center for Healthcare Engineering in 2005 and has awarded an additional $25 million to expand and extend its partnership with Purdue.

The foundation is named for benefactor Sam Regenstrief, who emigrated from Vienna to Indianapolis as a child and went on to launch the company that manufactured and popularized the low-cost home dishwasher, at one time producing 37 percent of the world's dishwashers in Connersville, Indiana. Regenstrief died in 1988.

Writer: Phillip Fiorini, 765-496-3133, pfiorini@purdue.edu
Sources: Mitch Daniels, president@purdue.edu
Steve Witz, 765-496-8303, switz@purdue.edu
Richard Zink, 765-494-4180, zinkr@purdue.edu
National Coalition for Infusion Therapy Safety

In 2010, the Association for the Advancement of Medical Instrumentation (AAMI) and the Food and Drug Administration (FDA) held an Infusion Device Summit to identify patient-safety issues related to infusion-pump administration management. The deliverable from the summit was a 48-page document, “Infusing Patients Safely,” that identified 13 priority issues that needed to be addressed.

AAMI organized and formed the National Coalition for Infusion Therapy Safety to address the ongoing patient-safety issues identified in the AAMI/FDA Infusion Device Summit. The two-year initiative has the following goals:3

1. To bring together pioneering hospitals, researchers, professional societies, industry, and other national leaders in infusion safety to agree upon evidence-based solutions to several key issues contributing to poor patient outcomes with infusion therapy.
2. To promote those solutions nationwide through a variety of modalities and via a range of educational materials.

The coalition is taking a phased approach to address the priority issues. The initial phase was a coalition kickoff event in March 2015 where key stakeholders (hospitals, patient advocates, national organizations and societies, regulators, and industry partners) gathered to build consensus and share knowledge. The second phase is to create multimedia campaigns to disseminate knowledge. Deliverables from phase 1 include conference proceedings, and phase 2 deliverables will be webinars, publications, event-based outreach, and web-based directories.

The expectation is the data-driven results and strategies to overcome lack of compliance with drug libraries and the creation of educational materials for administering multiple-line infusions will improve patient safety.

The Regenstrief Center for Healthcare Engineering (RCHE) has two roles in the coalition. The first role is as a thought leader in compliance with drug libraries. The IPI community is a rich source of knowledge and best practices for improving drug-library compliance. In the second role, AAMI has requested RCHE to provide project management for phase 2. Additional opportunities might include a role for DLRC to create and disseminate educational and training materials.

Best Paper Award

The Organization Made Us Do It: Demanding Formalization and Workaround Attributions

Benjamin Dunford, Ph.D.
Matthew Perrigino
Krannert School of Management

Abstract:

We call attention to an interesting paradox, which is that the same technologies intended to help employees do their jobs more safely result in numerous unintended and often overlooked cognitive, emotional, and physical demands on the users and recipients of those technologies. We argue that information technology and safety literatures have largely overlooked the unintended negative aspects of technology that have been articulated by organization theory. Toward a better understanding of how employees respond to this paradox, we apply the formalization literature from organization theory to introduce and test the concept of demanding formalization, which we define as perceptions of the extent to which the workflow blocks, constraints, and rules embedded in safety technologies place unintentional emotional, physical, and cognitive demands on employees. Thus, we offer a Janus-faced theoretical model that explores both the enabling and demanding aspects of formalization and how they apply to workarounds, which are idiosyncratic methods for overcoming workflow blocks. In this model, organizational workaround attributions play a central role in understanding the relationship between formalization attitudes and outcomes: demanding formalization facilitates a perception among employees that organizational dysfunction compels them to engage in workarounds, leading to organizational withdrawal and diminishing technology acceptance. We find empirical support for these assertions in a study of a large sample of nurses in three different US healthcare organizations.
Authors' comments:

A key message of the paper is that the designers and administrators of healthcare technologies often overlook the practical problems associated with new technologies and unintentionally create a dysfunctional culture that prompts nurses to feel no other choice than to engage in “workarounds,” reduce compliance with safety policies, or use technologies in unconventional ways. In this manner, organizational dysfunction can defeat the purpose of often hefty investments in those technologies. In short, “the organization made us do it.”

The paper is based entirely on the work we did with Regenstrief Center for Healthcare Engineering (RCHE) and the Infusion Pump Informatics (IPI) community over the last several years. We developed the paper in interactions with and site visits to three IPI hospitals: Eskenazi Health, University of Iowa Hospital and Clinics, and the University of Wisconsin Hospitals and Clinics. In the study, we combined survey data from nurses at these hospitals with archival data from microchips embedded in smart-infusion pumps uploaded to RCHE in the IPI database.

It is a great honor to win the award for multiple reasons. First, it is a strong signal that the paper will be published in a top-tier management journal, which is critical for building a lasting partnership between Krannert and RCHE. The research–practice gap has historically been the single biggest challenge confronting RCHE. Second, it brings a lot of visibility not only to Purdue and Krannert, but also to RCHE. Third, and perhaps most importantly, it provides confirming evidence that our research has the potential to be a conversation changer, fueling efforts to disseminate our findings in the nonacademic healthcare community. For example, these findings were discussed with Mary Alexander, CEO of the Infusion Nursing Society (INS), and will be presented at its conference this year. We also discussed plans to offer educational seminars to the INS community based on this research. Our findings will again be presented to pharmacists at the University of Wisconsin with a plan to make a campus visit to lead a seminar for nurses sometime later this year. Thus far, the message of the paper has been very well received by healthcare professionals.

The Academy of Management is the flagship academic association for management scholars. As of 2014, it had 18,166 members in 115 countries. Within the Academy are 25 divisions and interest groups. Among them, the Organization and Management Theory (OMT) Division is one of the most prominent, with 3,794 total members, and the most prestigious. Each year, the OMT division selects the best “empirical or conceptual paper . . . that offers a significant contribution to the field of organization and management theory.”
Health Systems Engineering Alliance

Need

The joint Institute of Medicine and National Academy of Engineering report on “Building a Better Delivery System: A New Engineering/Health Care Partnership” called for the establishment of “multidisciplinary centers at institutions of higher learning throughout the country capable of bringing together researchers, practitioners, educators, and students from appropriate fields of engineering, health sciences, management, social and behavioral sciences, and other disciplines to address the quality and productivity challenges facing the nation’s health care delivery system.” It was recommended that these centers have a three-fold mission:

1. Conduct basic and applied research on healthcare delivery.
2. Perform technology transfer on the use of systems-engineering tools throughout the healthcare delivery system.
3. Educate future engineering professionals and researchers.

Unfortunately, the reality is the vast majority of universities do not have the necessary critical mass of faculty to accomplish this, yet collectively we do. In response to this need, the Health Systems Engineering Alliance (HSEA) was formed.

Objective

Accelerate the development of health-systems engineering academic programs by providing a forum for sharing ideas, material, and lessons learned on both teaching and research about health-systems engineering.

Approach

The Regenstrief Center for Healthcare Engineering (RCHE) hosts a hub (https://catalyze-care.org/hsea) that provides a platform for these exchanges and represents yet another example of RCHE’s community-of-practice approach to dissemination.

Potential Impact

The opportunity is for a professional cultural change in the use of systems-engineering tools and information technologies within the healthcare community and to advance the training and development of healthcare, engineering, and management professionals with applications within this domain.

Partners

27 universities across the United States, Canada, and Mexico
Researchers

Various engineering faculty from the above universities

Current Status

HSEA’s focus has been initially on educationsharing health-systems engineering course materials, student activities, degree/track designs, internship formats, employment opportunities, and faculty–student exchanges. This year the alliance can report the following achievements:

1. Coordinated a five-session track at the INFORMS 2014 Conference
2. Posted information on 14 courses and 33 degree/certificate programs in the group’s archives
3. Hosted an international webinar on the 10-year evolution of a health-systems engineering course at the University of Wisconsin
4. Advanced a health-systems engineering scholarship program with proposed funding from the Association for the Advancement of Medical Instrumentation (AAMI).
Appendix C

Project Summaries

The research summaries described in this appendix provide additional details of RCHE’s current research activities. A subset of these projects will form the basis for RCHE’s new research initiatives and will become more integrated as RCHE transitions its research focus.
About the Project Summaries

The project summaries provide general information about RCHE’s projects. The guides below indicate key features of the project table on the next two pages:

1. Project Title
2. Page number
3. Research-to-Impact phase in which the project is currently working

Green highlight indicates new project.

Research-to-Impact Phases

A. Healthcare system evaluation with stakeholder input
B. Research and model development
C. Single-site pilot study and evaluation
D. Multiple-site pilot study and evaluation
E. Dissemination and evaluation
# Project Matrix

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<td>103</td>
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<tr>
<td><strong>Total</strong></td>
<td><strong>28</strong></td>
</tr>
</tbody>
</table>
Rating Healthcare

Research Team

Faculty
Tzung-tsieng Moh, Department of Mathematics, Purdue University

Staff
PI: Ping H. Huang, Regenstrief Center for Healthcare Engineering, Purdue University

Healthcare Partners
OurHealth

Research Direction

Competencies
Mathematical modeling

Research-to-Impact
Phase B (Research and model development)

Research Timeline
June 2013–May 2016

Project Summary

Healthcare Problem
On-site clinics administer a predefined set of primary-care services to contracted organizations. They agree to be accountable for the quality, appropriateness, and cost of this care for the members of these organizations and their dependents. As such, they face a broad assortment of healthcare challenges, from managing the preventive-care needs of their low-risk patients to providing referral guidance for their chronically ill patients.

While these on-site clinics are asked to improve on their population’s overall health, it is impractical for them to continuously manage every patient. Healthcare analytics are required to support these providers with the information they need to assess and stratify their patients. Armed with this information, they are better able to manage their patients’ health, properly integrate with other healthcare providers, drive better health outcomes, and decrease overall healthcare costs for not only their patients but their contracted organizations.

Research Objectives

Apply emerging mathematical-modeling techniques for multicriteria ranking and assess the effectiveness of the ranking method in its ability to assist in healthcare decision making. Key analytical requirements include the ability to measure a population’s overall health, as well as the relative health of the patients within that population.
Methodology

The methodology centers on creating a pairwise comparison matrix and uses its limiting power to produce a unique characteristic root that is reflective of each alternative’s relative rating.

Potential Impact

While the initial application of this methodology is in healthcare, it has the potential for much broader impact, in that any problem involving the evaluation of decision alternatives over multiple criteria is a candidate for this approach. Its significant strengths include scalability (e.g., number of criteria, population size), discrimination power, nonweighted and nonlinear approach, and ability to work with missing data.

Project Update

PATENT PENDING

A technology disclosure process has been initiated with Purdue’s Office of Technology Commercialization (OTC). Based on a thorough review of the pairwise comparison matrix methodology’s usefulness, novelty, and nonobviousness, OTC decided to submit a provisional patent to secure the methodology’s patentability and provide additional time to explore its commercial feasibility.

Other developments include:

- A manuscript titled “A non-linear non-weight method for multi-criteria decision making” was submitted to *Annals of Operations Research* on 1/29/2015.
- A presentation on “Assessing Patient and Population Health in Support of Accountable Care” was given at the *IIE Annual Conference 2015* on 5/31/2015.
- The methodology has been applied to the analysis of OurHealth’s population-health status. See the project summary titled: “Population Health Management Modeling to Support Accountable Care Delivery (Pilot: OurHealth).”
System Impact Measures

Research Team
Faculty/Staff PI: Poching DeLaurentis, Regenstrief Center for Healthcare Engineering, Purdue University
Healthcare Partners UW Health, Eskenazi Health

Research Direction
Competencies Data mining, Pattern and clustering analysis
Research-to-Impact Phase B (Research and model development)
Research Timeline August 2014–March 2015

Project Summary
Healthcare Problem The Infusion-Pump Informatics (IPI) System serves as a novel infusion-care, decision-support tool for pharmacists and nurses in the hospital setting. The infusion-drug alerts data and knowledge sharing within this IPI System-forged community of practice, along with the various charting and report tools on the system, provide clinicians with in-depth information on the infusion practice in each of the participating hospitals. From the viewpoints of the community coordinator and designer, it is important to understand and identify what drug-alert and user-usage patterns and clinical consequences may be linked and qualified as an impact of the adoption of the IPI System.

Research Objectives For each selected hospital in the community, we start with four impact measures, as follows.

1. Analyze the top 10 drugs over time; identify drugs of most interest by individual hospitals and the community as a whole.

2. Analyze the reduction in the number of alerts per device per drug of interest and its change over time, including their movement in the top 10 drugs.

3. Analyze the number and timing of drug-limit library updates, and identify their potential impact on items in 1 and 2 above.

4. Analyze the compliance percentage over time (by hospital), compliance-view activities and compliance-relevant changes.
made in the drug library (e.g., new addition to the drug library to improve compliance)

5. Compare and associate the aforementioned impact measures and their implication on clinical practice or infusion-care delivery.

**Methodology**

Drug-alert analysis on number, frequency, and pattern over time will be performed on selected hospitals. Selection will be based on their membership history, activeness in the community, and main user profiles. Research will be conducted on the methods related to pattern and clustering analysis and association rules in the field of data mining, with the most appropriate ones applied in this project. Any convergence on system usage and drug-alert patterns due to, possibly, community learning behavior is also of interest.

**Potential Impact**

Well-defined impact measures of the IPI System can demonstrate the values created by this specific community of practice and all the tools available online. The process of identifying and defining IPI System impact can further help us cast other important research questions pertinent to the adoption of this novel online system and its community. Potentially, we can create an index of system impact based on the aforementioned measures for system refinement, improvement, and design of similar e-communities of practice in the future.

**Project Update**

Some exploration of the drug-limit library and IPI System users’ usage patterns (such as reports generated, charts viewed) was done for one IPI System user (specifically, University of Wisconsin Hospital [UWH]) prior to starting the analysis on the system impact measures. This exercise greatly familiarized the research staff of the extensiveness of a drug-limit library, number and types of changes that can be made over time, system-usage patterns, IPI System capabilities, and insights into the complexity involved in implementing smart-infusion pumps in a hospital setting.

We began the analysis of the IPI System impact measures by focusing on the Top 10 Drugs history of UWH. The lists of the Top 10 Drugs per quarter (January to March, April to June, etc.), including the ranking and number of alerts from 2010 to early 2014, were downloaded and compiled for comparison and analysis. For UWH, twenty-six different drugs have shown up among the Top 10 over the years. These drugs were also examined and ranked by their total number of alerts, number of times they were on the Top 10 list, and a weighted index combining their ranking order and number of alerts. The different ranking methods showed consistent top offenders among the twenty-
six drugs. Moreover, significant time and effort were put into exploring ways to visualize these drugs and their Top 10 rankings over time, and a good option is utilizing a heat map in which drugs and time are two axes of a matrix and the color intensity in each cell reflects the position in the ranking. (See Figure 1 below.)

In addition to analyzing the Top 10 Drugs all together, the ranking movement of each of the drugs was teased out. Such ranking movement can be plotted in a run chart to analyze any shift, trend, or outlier. The run charts and their implication can later be used in conjunction with other analyses, such as changes made in the drug-limit library and compliance percentage over time (as outlined in the research objectives) to provide more insight into the impact of IPI System adoption.

Figure 1. (left) A heat map of the Top 10 drugs for University of Wisconsin Hospital

- Top 10 Drug Alerts per Device

The number of alerts per device provides a measure (ratio) of how many alerts per pump were generated per drug of interest. A heat map of the ratios across time for the Top 10 drugs is shown in Figure 2 below. As the cell colors in the circled area show in the chart of alerts per device, overall the number of alerts per device in 2014 has decreased from 2010 across the top drugs, and it indicates less alerts are happening in the hospital in general.

Figure 2. (left) Drug Alerts per Device for UWH

As these two figures show, top-ranked alerting drugs only reflect relative alerts and cannot indicate overall increase or reduction in number of alerts. Alerts-per-device ratios show trends of the number
of alerts per drug. Therefore, putting the figures side by side, the ranking heat map and alerts-per-device run chart combined provide a better picture of the overall status of alerts over time, as shown in Figure 3 below. For example, Propofol stayed as a top alerting drug throughout the years, but the alerts-per-device ratio indicates the number of alerts has decreased some over the period.

Peperacilin/Tazo, on the other hand, has increased in ranking among the top alerting drugs, although the number of alerts per device did not change much in general.

- **UWH Vancomycin Alerts in 2013**

The run chart above shows that there is a significant increase in Vancomycin alerts during 2013, which led to a more in-depth investigation into the medication. We discovered from the data in the IPI System that there was a drug-limit library change for Vancomycin at the end of March 2013 and the beginning of April, which most likely caused the increase in the number of Vancomycin alerts. Its alert numbers slowly declined to the prior level after three quarters, which may indicate that the nursing staff had adjusted to the change.
• Eskenazi Comparison
Similar analysis was done for Eskenazi Health. Their heat maps of the top 10 ranked drugs and alerts per device along with the line charts are shown in Figure 5 below.

![Figure 5](image)

Figure 5. Eskenazi Leading Five of Top 10 Drug Views, side-by-side

The trends of these two charts correspond well with one another. Since we know that the overall alert numbers were up in 2014, it means the average alert rates are stable for these drugs.

• Cameron Memorial Community Hospital
Similar analysis was planned for an IPI member hospital of a smaller size. Cameron Memorial Community Hospital is a 25-bed Critical Access general community hospital. However, due to its size (and patient volume), it appeared that there were not enough alerts data to produce plots and draw meaningful conclusions for such a small hospital. We need to keep that in mind for future studies (including how to study and make fair comparisons of small hospitals).

Summary
An in-depth analysis of the drug alerts, their rankings, and alerts-per-device ratios can be informative of what potential errors could have been made but averted while administering drug infusions. However, we did realize that since clinical outcomes or other types of clinical or administrative data are not currently linked or correlated to the available drug-alert data, analysis of the clinical impact of the IPI System may not be possible.

This project concluded as of March 2015. An extension of this work has been proposed and the new project will focus on quantifying the value provided by employing smart pumps and the IPI System using established research results on adverse drug events. We also need to explore more about how other types of clinical data (e.g., administrative, pharmacy records, etc.) may be combined with IPI alerts data to answer some other important and relevant research questions.
Smart Infusion Pump Alert Threshold Decision Support

Project Team

Faculty
PI: Steven J. Landry, Industrial Engineering, Purdue University
Yuval Bitan, Cognitive Technologies Laboratory, Chicago, IL

Students
TBD graduate assistant (summer, 2015), Industrial Engineering
Fem Ozcan (undergraduate, spring 2015), Industrial Engineering
Ryan Widjaja (undergraduate, fall 2014), Industrial Engineering
Ziya Zhao (undergraduate, spring and fall 2013), Industrial Engineering
Jeong Joon Boo (undergraduate, spring 2013), Industrial Engineering
Karen Rockwell (undergraduate, spring 2013), Industrial Engineering
Adithya Raghavan (graduate, spring 2013), Industrial Engineering
Nsikak Udo-Imeh (graduate, fall 2012), Industrial Engineering
Harsh Wardhan Aggarwal (graduate, fall, 2012), Industrial Engineering
Hyo-sang Yoo (graduate, fall 2011), Industrial Engineering

Healthcare Partner(s)
All interested IPI members

Research Direction

Competencies
Human factors

Research-to-Impact Phase
Phase B (Research and model development)

Research Timeline
October 2014–May 2016

Project Summary

Healthcare Problem
The current practice to reduce infusion-pump guardrail alerts is to review the drug/profile/field-limit combinations that produce the most frequent alerts and potentially adjust those thresholds to reduce the number of alerts. This review is limited to approximately the top 5 most frequent alerts, out of thousands of such combinations, and is conducted approximately monthly. This is insufficient for several reasons. First, a focus on frequencies is misplaced. The focus should be on performance, regardless of frequency. While true, alerts that sound frequently typically have the most number of false alarms, it could also be that the alerts need to sound to identify a dangerous condition. Second, these reviews typically focus on alerts that occur within individual hospitals, without reviewing across all the hospitals in the coalition.
Research Objectives

1. To identify the effect of simple decision rules on the number of false alarms and missed detections, and

2. To improve the practice of alert threshold updating in the IPI guardrail library through the development and use of a decision-support tool.

Methodology

An algorithm has been developed to review the infusion-pump informatics data to identify all poorly performing alert thresholds. In addition to providing a coded algorithm for re-accomplishing this analysis as needed, the list of poor performers will be identified to provide guidance on simple changes to all the combinations of drug/profile/field limits. In addition, the algorithm, along with an associated tool, can identify the effect, in terms of performance (missed detections/false alarms), or altering the guard rail. This tool will be implemented within the IPI tool and subjected to simple human–computer interaction testing to improve the interface and to allow users to interact with the tool.

We have also begun collaboration with Dr. Yuval Bitan of HumanEra on identifying the mental models of nurses when interacting with the infusion pump system.

Potential Impact

The effect will be to (a) reduce alert fatigue by minimizing the number of false alarms without increasing important missed detections, and (b) to improve library-review practice by providing an intuitive interface to help make accurate judgments about a large number of thresholds quickly.

Project Update

A prototype algorithm and system have been developed. The algorithm was implemented within a database. An analysis of the impact of a simple rule for setting thresholds was conducted and indicated that a simple threshold will reduce the total number of alarms, while also reducing missed detections for at least some drug/profile/field-limit combinations. This work was presented in poster form at the 2015 International Symposium on Human Factors and Ergonomics in Healthcare, as well as at the spring 2015 Infusion Pump Informatics Conference.

I have had numerous teleconferences with Dr. Bitan, and we have begun developing the survey that we will use in support of the mental model research.

Lastly, a larger NSF–NIH proposal was developed and submitted as an offshoot of this work. We have not yet heard back on its status.
Nursing Attitudes and Perceived Causes of IV Pump Workarounds

Research Team
Faculty
PI: Ben Dunford, Management, Purdue University
Students
Matthew Perrigino, Management
Healthcare Partners
University of Iowa Health Care, Eskenazi Health, and the University of Wisconsin Hospitals and Clinics

Research Direction
Competencies
Team dynamics
Research-to-Impact
Phase E (Dissemination and evaluation)
Research Timeline
August 2012–December 2015

Project Summary
Healthcare Problem
While workarounds are a common part of any work environment, they can signal larger process issues that need to be addressed. In the case of IV pumps, nurses are on the front lines of using the pumps, but are rarely involved in the process of developing or installing the pumps. Smart-IV pumps should provide additional patient-safety benefits; however, if nurses are having difficulties and need to use workarounds, these benefits may not be realized.

This project seeks to understand attitudes and perceived causes of workarounds with smart-IV pumps. As an earlier stage research project, the researcher is also seeking to develop and evaluate potential new research questions.

Research Objectives
1. Establish a list of potential causes of workarounds.
2. Examine potential methods of perpetuating workarounds through the workplace.

Methodology
An anonymous online survey was conducted. Sample size is approximately 800 nurses across all three institutions. The survey used a variety of question formats, including open-ended, dichotomous, and Likert scale.
Potential Impact

If workaround causes can be identified, changes may be able to be made to avoid the need for disruptive workarounds, potentially increasing the likelihood that nurses would use the pumps and their safety features more.

Project Update

In our pilot study of three US health systems (Eskenazi, U. Iowa, and U. Wisconsin), now conditionally accepted for publication in the *Journal of Patient Safety*, we began to explore the causal mechanisms behind contagion effects in the usage of smart infusion-pump devices. We found strong evidence that contagion effects may be due to how nurses are trained and typically solve problems (by going to peers rather than administrators or managers for troubleshooting). However, given that our pilot study was based on a short anonymous survey, the data are limited in the ability to more completely explore the existence of contagion effects at various levels of analysis. Therefore, we have begun to analyze the IPI data that comes directly from the smart pumps themselves to investigate our hypotheses that noncompliance with smart-pump safety procedures are heavily influenced by social mechanisms. In short, we are looking for evidence that workarounds and noncompliance are driven by the culture of an organizational unit.

We examined contagion effects using the “time to override” variable in the CatalyzeCare system. Two different approaches were taken. First, the binary approach considered any override that was recorded as lasting from 0 to 2 seconds as a workaround, while overrides ranging from 3 to 20 seconds were not. This approach was taken because overriding an alert during the time frame of 0 to 2 seconds would not allow enough time for the alert to be processed as a conscious thought and to subsequently result in a reasoned or informed decision. However, realizing that there could be disagreement around this delineation, the second approach treated the time to override as a continuous variable ranging from 0 to 20 seconds. In this sense, we avoided the need to create a cutoff point, where lower values of the continuous scale may be considered as workarounds and higher values considered as a proxy for problem-solving behaviors. Results using both approaches were virtually identical, so for simplicity, only the results from the second approach are discussed below.
To attempt to assess whether response times are an individual-level phenomenon or are driven by higher-level influences (e.g., due to department- or facility-level influences), we ran multilevel analyses to partition out the variance across different levels. In total, there were 432,517 overrides (all ranging from 0 to 20 seconds) from January 2013 through March 2014. These overrides were nested in 11,963 smart pumps, which were nested in 19 different hospital profiles. The 19 different profiles were nested in 54 different hospital facilities, which were nested in 11 hospital systems. Different three-level combinations were explored with results from two of these reported below.

<table>
<thead>
<tr>
<th></th>
<th>January 2013</th>
<th>February 2013</th>
<th>March 2013</th>
<th>All Periods</th>
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</thead>
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<tr>
<td>Override</td>
<td>.71</td>
<td>.73</td>
<td>.72</td>
<td>.83</td>
</tr>
<tr>
<td>Smart Pump</td>
<td>.20</td>
<td>.16</td>
<td>.13</td>
<td>.16</td>
</tr>
<tr>
<td>Facility</td>
<td>.08</td>
<td>.10</td>
<td>.15</td>
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</table>

The results above treat individual overrides as the level 1 variable, smart pumps as the level 2 variable, and facility as the level 3 variable. The ICCs indicate that approximately 70% to 80% of the variance in response times is attributable to the individual nurse. However, an ICC equal to or greater than .05 generally indicates that nesting effects cannot be ignored and other influences are beyond individual factors. As demonstrated by the table above, variance attributable to the smart pump explains on average approximately 16% of the variance in workarounds. Finally, for individual months, it also appears that variance exists in workarounds at the facility level, as well. The results presented in this table may be interpreted the same way; the only difference is that “profile” was treated as the level 3 variable instead of “facility.” These results are consistent with the results presented above: although workarounds are driven primarily by the individual-nurse level, variance attributable to the specific smart pump and the hospital profile also explain significant amounts of variance. Based on these preliminary analyses, it appears that there may be evidence of a “response time contagion,” where response times are due to these higher-level influences.
Our plan is to continue to refine these analyses, accounting for possible confounding factors that may be influencing the results. We are working with Aurora Health system in Wisconsin to identify possible confounding issues in this analysis. If we can identify and control for potentially confounding influences and get approval from enough hospitals for an additional survey distribution, we plan to use the IPI data and the analyses we described above in combination with a survey administration at multiple health systems to explore how shared formalization attitudes at various levels of analysis influence contagion effects in how smart pumps are used. For example, we hypothesize that when there is a culture among nurses in departments such that smart pumps are considered to be a source of unanticipated physical and emotional strain, they are more likely to override alerts in less than 2 seconds and contagion effects in override-response times are likely to be more prevalent. In the event that we do not get sufficient support for a survey data collection, we will conduct a smaller study on contagion effects in noncompliance with smart-pump procedures.

Our plan was to continue to refine the analyses based on the collected data and attempt to gather additional survey-based data from various healthcare facilities.

First, multiple papers and presentations have resulted from additional analyses of the existing data.

- One paper was published in the *Journal of Patient Safety* using the pilot-survey data. The article is currently in press. This article was primarily descriptive, focusing on the various factors (e.g., technological, organizational, and individual) contributing to the proliferation of workarounds.

- We also have presented at the 7th Annual Implementation and Dissemination Conference in Washington, D.C. (December 2014), addressing how specific support translated to improved smart-pump reactions, finding that general support is a necessary but insufficient requisite for improving nurses’ perceptions related to smart-infusion pumps. This paper has been conditionally accepted at the peer-reviewed journal *Health Care Management Review*, and is currently undergoing revisions.

- Using the override data from the IPI database, a paper was accepted for presentation at the annual *Labor and Employment Relations Association (LERA)* meeting, May 28–
31, 2015, in Pittsburgh, PA. In receiving a best-paper selection, we have been invited to contribute a full-length manuscript for publication in the journal, *Advances in Labor Relations (AILR).*

- Using the survey-based data, two papers, focusing on the distinction between how nurses perceive smart pumps to be disruptive to themselves and beneficial to patients, have been accepted to the *Annual Academy of Management* meeting, August 7–11, 2015, in Vancouver, BC. One paper merited a best-paper award and will be published in the *Academy of Management Conference Proceedings.* A third paper with a similar focus will be presented at the *Infusion Nurses Society Conference,* May 17–21, 2015, in Louisville, KY.

Second, in regard to future data collection, multiple connections were established at the latest IPI meeting (April 2015 in Iowa City, IA), and conversations regarding potential collaboration have been initiated. Interested providers include Aurora Health Care, University of Nebraska, Cameron Memorial Community Hospital, IU Health, and Community Health. Additionally, the previous contacts at Iowa, Wisconsin, and Eskenazi Health remain interested in collaborating with additional surveys to follow up from the initial data collection.
Development of the Infusion Pump Informatics System

Research Team

Faculty
PI: Ann Christine Catlin, ITaP/Research Computing, Purdue University

Students
Sudheera Fernando
Sumudinie Fernando
Ruchith Fernando
Ruwan Gamage

Healthcare Partners
Aurora Health
Cameron Memorial Community Hospital
Community Health Network
Deaconess Hospital
Eskenazi Health
Franciscan St. Francis Health
Good Samaritan Hospital Vincennes
IU Health
Indianapolis Roudebush VAMC
Intermountain Healthcare
St. Mary’s Hospital
University of Iowa Health Care
University of Nebraska Hospital
University of Wisconsin Hospital

Research Direction

Competencies
Data visualization
Databases

Research-to-Impact Phase
Phase E (Dissemination and evaluation)

Research Timeline
April 2013–June 2015

Project Summary

Healthcare Problem
The alert data collected by infusion pumps can be used to create improvements in patient safety; however, the data must be in a format that is reliable, timely, and user-friendly. The collection capabilities that accompany infusion pumps often provide limited data-analysis capabilities, which may not be interactive enough to answer more detailed questions.
Research Objectives

The objectives of this segment include:

1. Integrate the new Carefusion "Knowledge Portal" standard for alert reporting and counting.
2. Integrate Carefusion "Knowledge Portal" compliance data.
3. Establish standards for IPI-alert analysis based on IPI community consensus.
4. Integrate Baxter Sigma Spectrum infusion-pump data.
5. Upgrade and extend support for Hospira smart-pump alert and compliance data.
6. Establish terminology standards across smart-pump manufacturers and hospital safety groups when using IPI.
7. Maintain the IPI infrastructure: database, middleware, data processors, and graphical interface.
8. Support users.

Potential Impact

The analysis enabled through this project helps hospitals identify areas for improvement and education in their IV medication-administration process. The community of practice that is growing through this project provides professional networking and support for healthcare providers focused on this issue and helps them disseminate important results to their colleagues for even greater improvement.

Project Update

Development and support activities continue for the IPI system. The completion of the Baxter integration for alert data and the onboarding of Intermountain Healthcare highlights this period.
Supporting Communities of Practice to Improve Healthcare Delivery

Research Team

Faculty
Steve Witz, Regenstrief Center for Healthcare Engineering (RCHE), Purdue University

Staff
PI: Rich Zink, RCHE, Purdue University
Ken Musselman, RCHE, Purdue University

Healthcare Partners

Infusion Pump Informatics (IPI) Providers:
- Aurora Health Care
- Cameron Memorial Community Hospital
- Community Health Network
- Community United Methodist Hospital
- Deaconess Hospital
- Eskenazi Health
- Franciscan St. Francis Health
- Good Samaritan Hospital Vincennes
- IU Health
- Indianapolis Roudebush VAMC
- Madison, WI VA
- Metro Health Hospital—Wyoming, MI
- Parkview Health System
- St. Mary’s Hospital
- University of Iowa Health Care
- University of Nebraska Hospital
- University of Wisconsin Hospital
- Witham Hospital

Physiological Monitor Providers:
- To be determined.

Infusion Pump Informatics (IPI) Vendors:
- Carefusion
- Hospira
- Baxter

Physiological Monitor Vendors:
- GE Healthcare
- Philips Healthcare
- Draeger Medical
- Covidien
- Spacelabs Healthcare
**Research Direction**

- Competencies: Community building
- Research-to-Impact: Phase E (Dissemination and evaluation)
- Research Timeline: Ongoing

**Project Summary**

**Healthcare Problem**
Alarm hazards were identified as the number 1 hazard for 2014 by the ECRI Institute. Alarm fatigue continues to be a problem for nurses in the clinical environment.

**Research Objectives**
The evidence-based communities of practice approach provides sharing of information between healthcare providers and vendors to improve safety, efficacy, and efficiency when using infusion pumps and/or physiological monitors. This includes improving patient safety, reducing alert fatigue, improving drug-library management, and so on.

**Methodology**
The scientific-collaboration platform, www.CatalyzeCare.org, is leveraged as the collaboration space for providers and researchers. Providers share information within the community via document repositories, containing drug libraries and other documents, and threaded discussions allowing clinicians to get information and answers from their peers.

RCHE provides the collaboration space, supports the community by hosting regular community meetings, and provides technical support for using CatalyzeCare.

**Potential Impact**
Supporting this community of practice provides a dissemination vehicle for RCHE research. Additionally, communities of practice are being developed nationwide as a method of addressing the need for research dissemination. RCHE’s support of and research into communities of practice can assist others in establishing successful communities.

**Project Update**
Based on the success of the evidence-based community-of-practice model demonstrated by the IPI community, this project is expanding to support a new, second group focused on physiological monitor alarms using CatalyzeCare.org.
Improving Primary Care Delivery Through Allocation of Resources

Research Team

Faculty
PI: W. Bart Collins, Communications, Purdue University
Brandon Pope, Industrial Engineering, Baylor Health Sciences
Cleveland Shields, Human Development & Family Sciences, Purdue University
Steve Witz, Regenstrief Center for Healthcare Engineering, Purdue University
Lingsong Zhang, Statistics, Purdue University
Mike Zentner, ITaP/Research Computing, Purdue University

Students
Ravi Rajesvaran, Statistics and Mathematics

Healthcare Partners
Amy LaHood, MD, MPH, FAAFP, St. Vincent
Curt Ward, MD, MBA, FAAFP, Program Director, St. Vincent Family Medicine Residency Program
Maurice Magdi Henein, MD, Clinical Faculty at St. Vincent Family Medicine
Josh McKinnon, MD, St. Vincent Health
Jimmy Zimmerman, MD, St. Vincent Health

Research Direction

Competencies
Patient-centeredness
Model development

Research-to-Impact
Phase C (Single-site pilot study and evaluation)

Research Timeline
July 2012–June 2014

Project Summary

Healthcare Problem
The delivery of high quality patient-centered care (PCC) is essential for improving the health of Americans and for containing the costs of medical care. The quality of PCC delivered in a healthcare system is difficult to measure, which limits the healthcare system’s ability to provide and improve their delivery of PCC. A critical barrier to providing patient-centered care is the potential disconnect between patients’ evidence-based needs and personal preferences. This study seeks to improve healthcare by improving the measurement of PCC and understanding its enablers and benefits.
Research Objectives

1. To identify gaps in patient and physician perceptions of needs, wants, and the primary care that is delivered.

2. To identify the sources and consequences of these gaps.

Methodology

Retrospective chart reviews will help identify relevant health outcomes of the patients in the cohort. This data on health outcomes will serve as initial evidence of the relationship between various measures of patient-centeredness and health outcomes. We have identified and are in the process of writing a proposal (using our pilot data for support) to fund direct comparison of the most influential PCC measures across a range of patient outcomes in the context of a large family and internal-medicine clinic with a large residency-training component.

Potential Impact

This project will contribute to measurement methods for patient-centeredness by developing a method that accounts for multiple dimensions, as well as resource restrictions. It will impact patients when the findings are disseminated in resident-training programs to help resident physicians learn about meeting and managing patient perceptions and expectations.

Project Update

In phase two of our research, we conducted a secondary chart review six months after the survey protocol to determine the extent to which patient-centered care was associated with longer-term outcomes, including adherence to follow-up visits and health status. Though our N was relatively low in this pilot, and we were measuring outcomes six months following a single consultation, patient-centered care was associated with some health-status changes, including blood-pressure improvements. PCC delivery was also stronger, based on racial, gender, and age similarities with the provider. Active data collection on this project is closed. Results have been presented at two of St. Vincent’s annual research conferences, and manuscripts are under development for publication in peer-reviewed outlets.
Hospital Readmissions (Pilot: BayCare)

Research Team

Faculty
Hong Wan, Industrial Engineering, Purdue University
Brandon Pope, Industrial Engineering, Baylor Medical Center
Lingsong Zhang, Statistics, Purdue University
Maribeth Slebodnik, Libraries, Purdue University
Jose Zayas-Castro, Industrial and Management Systems Engineering, University of South Florida
Peter Fabri, MD, Industrial and Management Systems Engineering, University of South Florida
Laila Cure, Industrial and Manufacturing Engineering, Western Michigan University

Staff
PI: Ken Musselman, Regenstrief Center for Healthcare Engineering, Purdue University
Michael Zentner, ITaP/Research Computing, Purdue University
Peter Baker, Cyber Center, Purdue University
Jia Xu, Cyber Center, Purdue University
Zhiyi Tian, Regenstrief Center for Healthcare Engineering, Purdue University

Students
Cody Mullen, Regenstrief Center for Healthcare Engineering
Kalada Kienka, Cyber Center
Florentino Rico Fontalvo, Industrial and Management Systems Engineering, University of South Florida
Diego Martinez, Industrial and Management Systems Engineering, University of South Florida
Yazhuo Liu, Industrial and Management Systems Engineering, University of South Florida
Ching-Wei Cheng, Statistics

Healthcare Partners
BayCare Health System

11 hospitals in and around Tampa, Florida
- 8 general and three specialty hospitals (women’s, children’s and long-term care)
  - BayCare Alliant Hospital
  - Mease Countryside Hospital
  - Mease Dunedin Hospital
  - Morton Plant Hospital
  - Morton Plant North Bay Hospital
  - St. Anthony’s Hospital
  - South Florida Baptist Hospital
  - St. Joseph’s Hospital
  - St. Joseph’s Children’s Hospital
  - St. Joseph’s Hospital—North
  - St. Joseph’s Women’s Hospital
Bed size range: 108–687
**Research Direction**

**Competencies**
- Data analysis
- Modeling
- Statistical analysis

**Research-to-Impact**
- Phase D (Multisite pilot study and evaluation)

**Research Timeline**
- I: April 2010–May 2011
- II: June 2011–June 2012
- III: July 2012–August 2012
- IV: August 2012–June 2013
- V: July–June 2015

**Project Summary**

**Healthcare Problem**
Existing studies of hospital readmissions typically focus on specific diagnoses, age groups, discharge dispositions, payers, or hospitals, and often use small samples. It is not clear how predictive models generated from such studies generalize across diseases, hospitals, or time frames. The goal of this project is to construct a generic model of readmission risk, which can be applied to the majority of inpatient admissions, and to validate the model’s ability to extrapolate across hospital sites and time frames. To better convey the nature of the model, a computer application will be built for demonstration purposes.

**Research Objectives**
1. Refine readmissions risk statistical models based on latest research findings.
2. Embellish the Readmission App code to be better aligned internally.
3. Update and examine the fit of the readmission prediction model with the latest input factors.
4. Conduct a comparative analysis of the readmission prediction model against another hospital site.
5. Disseminate the readmission research findings to involve hospitals and other appropriate organizations.

**Methodology**
- Use logistics regression to predict 30-day readmission rates for patients.
- Construct an optimization model to establish patient-risk classes and recommended discharge interventions for each patient class based on objective-based intervention characteristics, such as efficacy and cost.
- Build a web-based app for showcasing a Discharge Intervention Decision-Support System that can convey effective and
appropriate use of prediction and intervention recommendation models.

Potential Impact

To help mitigate partnering hospitals’ readmission risks by implementing patient-appropriate care transition strategies in order to improve the hospital’s quality of care and to have them avoid costly penalties.

Project Update

This represents a final update on this project. The most significant results were as follows:

- Readmission risk predictors

<table>
<thead>
<tr>
<th>Category</th>
<th>Independent Variable</th>
</tr>
</thead>
<tbody>
<tr>
<td>Demographics</td>
<td>Gender, Age, Race, Marital Status, Language, Payer Class</td>
</tr>
<tr>
<td>Historical Utilization</td>
<td>Prior admissions within last 3 months</td>
</tr>
<tr>
<td></td>
<td>Prior admissions within last 3 to 6 months</td>
</tr>
<tr>
<td></td>
<td>Charlson Comorbidity Index</td>
</tr>
<tr>
<td></td>
<td>Days since last discharge</td>
</tr>
<tr>
<td>Current Utilization</td>
<td>Admission type</td>
</tr>
<tr>
<td></td>
<td>Disease Severity Index</td>
</tr>
<tr>
<td></td>
<td>Time on ventilator</td>
</tr>
<tr>
<td></td>
<td>Length of stay</td>
</tr>
<tr>
<td></td>
<td>Discharge disposition</td>
</tr>
<tr>
<td></td>
<td>Behavioral flag substance</td>
</tr>
<tr>
<td></td>
<td>Behavioral flag nonsubstance</td>
</tr>
<tr>
<td></td>
<td>Principal diagnosis (CCS single-level)</td>
</tr>
<tr>
<td></td>
<td>Principal procedure (CCS single-level)</td>
</tr>
</tbody>
</table>

Overall readmission risk-prediction model’s C-statistic: 0.722
The relative importance of each predictor is shown in the graph below. The most important predictors were found to be discharge disposition, principal diagnosis, admission type, and time since previous discharge (or days since last discharge). Looking at it by hospital, these four predictors were found to be in the top 5, regardless of the hospital.
For model longevity, a one-year model was used, and it was found to need recalibration after two years, as seen in the plot below. Operationally, this should provide adequate enough time between model recalibrations.
For all patients who were readmitted within 30 days, the table below shows for the top 10% of all discharges by diagnosis that 20% return within 3 days and 50% within roughly 10 days. This implies, regardless of the diagnosis, an intervention must occur quickly if it is to have significant impact. Seen another way, if one waits 3 weeks (i.e., 21 days) to intervene, three-quarters of the readmissions that are going to happen have likely already occurred.

<table>
<thead>
<tr>
<th>Principal Diagnosis (CCS Level 2)</th>
<th># ≤ 30 D</th>
<th>20th</th>
<th>50th</th>
<th>75th</th>
</tr>
</thead>
<tbody>
<tr>
<td>15.1 Liveborn [218.]</td>
<td>2,116</td>
<td>1</td>
<td>8</td>
<td>19</td>
</tr>
<tr>
<td>7.2 Diseases of the heart</td>
<td>6,926</td>
<td>1</td>
<td>8</td>
<td>17</td>
</tr>
<tr>
<td>5.8 Mood disorders</td>
<td>3,597</td>
<td>2</td>
<td>9</td>
<td>18</td>
</tr>
<tr>
<td>8.1 Respiratory infections</td>
<td>1,915</td>
<td>3</td>
<td>10</td>
<td>19</td>
</tr>
<tr>
<td>9.6 Lower gastrointestinal disorders</td>
<td>1,898</td>
<td>3</td>
<td>10</td>
<td>18</td>
</tr>
<tr>
<td>10.1 Diseases of the urinary system</td>
<td>1,711</td>
<td>3</td>
<td>10</td>
<td>19</td>
</tr>
<tr>
<td>16.2 Fractures</td>
<td>1,277</td>
<td>3</td>
<td>10</td>
<td>19</td>
</tr>
<tr>
<td>7.3 Cerebrovascular disease</td>
<td>1,332</td>
<td>2</td>
<td>9</td>
<td>18</td>
</tr>
<tr>
<td>13.3 Spondylosis; intervertebral disc disorders; other back problems [205.]</td>
<td>636</td>
<td>3</td>
<td>10</td>
<td>18</td>
</tr>
<tr>
<td>16.10 Complications</td>
<td>1,800</td>
<td>3</td>
<td>9</td>
<td>18</td>
</tr>
<tr>
<td>13.2 Non-traumatic joint disorders</td>
<td>550</td>
<td>3</td>
<td>11</td>
<td>19</td>
</tr>
<tr>
<td>5.10 Schizophrenia and other psychotic disorders</td>
<td>2,734</td>
<td>3</td>
<td>9</td>
<td>18</td>
</tr>
<tr>
<td>12.1 Skin and subcutaneous tissue infections [197.]</td>
<td>819</td>
<td>2</td>
<td>9</td>
<td>18</td>
</tr>
<tr>
<td>17.1 Symptoms; signs; and ill-defined conditions</td>
<td>953</td>
<td>3</td>
<td>10</td>
<td>19</td>
</tr>
<tr>
<td>8.2 Chronic obstructive pulmonary disease and bronchiectasis [127.]</td>
<td>1,425</td>
<td>4</td>
<td>12</td>
<td>21</td>
</tr>
<tr>
<td>10.3 Diseases of female genital organs</td>
<td>392</td>
<td>2</td>
<td>7</td>
<td>16</td>
</tr>
</tbody>
</table>
To provide evidence of the ability of predictive readmission models to generalize across hospitals, the St. Joseph Hospital applied the derived readmission risk-prediction model to ten other BayCare hospitals. This model achieved a C-statistic of 0.706 and generalized quite well across the rest of BayCare, as shown in the table below.

<table>
<thead>
<tr>
<th>Hospital</th>
<th>C-statistic</th>
</tr>
</thead>
<tbody>
<tr>
<td>BayCare Alliant Hospital</td>
<td>0.722</td>
</tr>
<tr>
<td>Mease Countryside Hospital</td>
<td>0.705</td>
</tr>
<tr>
<td>Mease Dunedin Hospital</td>
<td>0.715</td>
</tr>
<tr>
<td>Morton Plant Hospital</td>
<td>0.704</td>
</tr>
<tr>
<td>Morton Plant North Bay Hospital</td>
<td>0.711</td>
</tr>
<tr>
<td>St. Anthony’s Hospital</td>
<td>0.704</td>
</tr>
<tr>
<td>South Florida Baptist Hospital</td>
<td>0.718</td>
</tr>
<tr>
<td>St. Joseph’s Children’s Hospital</td>
<td>0.703</td>
</tr>
<tr>
<td>St. Joseph’s Hospital—North</td>
<td>0.721</td>
</tr>
<tr>
<td>St. Joseph’s Women’s Hospital</td>
<td>0.707</td>
</tr>
</tbody>
</table>
Below is a histogram and calibration plot of predicted 30-day readmissions using the St. Joseph Hospital model as the derivation model. It shows the prediction model is very well calibrated for patients with a probability of readmission (within 30 days) less than or equal to 0.40 when tested against the ten other BayCare hospitals. The model remains well calibrated, although slightly less so, for patients with probability between 0.40 and 0.50. For patients with predicted risk above 0.50, the model appears to overpredict. However, this is only for a relatively small percentage of the population who are already observed to be at very high risk (above 0.50).
The table below addresses cross-time validation for various St. Joseph Hospital’s derived readmission risk-prediction models, a different model for each of the first five years. As expected, the derivation years (i.e., the first year in a series) outperform the validation years. Yet, while its performance falls off, it remains relatively stable across the outer years.

<table>
<thead>
<tr>
<th>Model</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>m₁</td>
<td>0.75</td>
<td>0.696</td>
<td>0.689</td>
<td>0.681</td>
<td>0.681</td>
<td>0.688</td>
</tr>
<tr>
<td>m₂</td>
<td>---</td>
<td>0.750</td>
<td>0.682</td>
<td>0.683</td>
<td>0.688</td>
<td>0.690</td>
</tr>
<tr>
<td>m₃</td>
<td>---</td>
<td>---</td>
<td>0.742</td>
<td>0.689</td>
<td>0.683</td>
<td>0.697</td>
</tr>
<tr>
<td>m₄</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>0.738</td>
<td>0.682</td>
<td>0.701</td>
</tr>
<tr>
<td>m₅</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>0.736</td>
<td>0.697</td>
</tr>
</tbody>
</table>
Using only BayCare’s independent variable list, the table below shows what independent variables (indicated in bold) were significant readmission risk predictors at Cleveland Clinic. The C-statistic for this model of 0.6654, which is (as expected) less than the overall model C-statistic of 0.722, but is interestingly reasonable. However, it is significantly lower than the St. Joseph Hospital derived model applied to BayCare’s ten other hospitals, which ranges from 0.703-0.722.

<table>
<thead>
<tr>
<th>Category</th>
<th>BayCare’s Independent Variable</th>
</tr>
</thead>
<tbody>
<tr>
<td>Demographics</td>
<td>Gender, Age, Race, Marital Status, Language, Payer Class</td>
</tr>
<tr>
<td>Historical Utilization</td>
<td>Prior admissions within last 3 months, Prior admissions within 3 to 6 months, Charlson Comorbidity Index, Days since last discharge</td>
</tr>
<tr>
<td>Current Utilization</td>
<td>Admission type, Disease Severity Index, Time on ventilator, Length of stay, Discharge disposition</td>
</tr>
<tr>
<td></td>
<td>Behavioral flag substance, Behavioral flag nonsubstance, Principal diagnosis (CCS single-level), Principal procedure (CCS single-level)</td>
</tr>
</tbody>
</table>
Deliverables

- A patient stratification analysis was done on St. Joseph Hospital patients. Somewhat surprisingly, readmission risk was not found to be a significant stratification factor. Patients more strongly associated (and disassociated) with other factors. However, since the interest was in assessing factors for readmitted patients, readmission risk was forced to be the top-level cut, and the patients were subdivided into low, medium, and high 30-day readmission risks. The most significant patient characteristics (outside of their readmission probability) that best described these three risk groups differed. This result could lead to insights into how to better design and apply readmission interventions.


3. Demonstration app (http://tinyurl.com/lnwhsgf) comprised of a readmission-prediction engine (to estimate a patient’s readmission risk based on a predetermined set of predictors) and an intervention engine (to recommend what interventions are most appropriate for a given patient given the patient’s readmission risk and the cost and efficacy of each intervention)

4. Readmissions app user guide: “How to demonstrate the 30-day readmission app”
All-Cause Unplanned and Preventable Readmissions Reduction

Research Team

Faculty
Lingsong Zhang, Statistics, Purdue University
Karen S. Yehle, Nursing, Purdue University

Staff
PI: Ken Musselman, RCHE, Purdue University
Benjavan Upatising, RCHE, Purdue University
Kit Klutzke, RCHE, Purdue University
Rich Zink, RCHE, Purdue University

Students
Donglai Chen, Statistics, Purdue University
Saiya Sheth, London School of Hygiene and Tropical Medicine

Healthcare Partner
Cleveland Clinic
- Main Campus
- Fairview
- Hillcrest
- Marymount
- South Pointe
- Lakewood
- Medina
- Medina
- Lutheran
- Euclid

Research Direction

Competencies
Data mining
Statistical analysis
Project management

Research-to-Impact
Phase D (Multisite pilot study and evaluation)

Research Timeline
May 2014–February 2016

Project Summary

Healthcare Problem
Unplanned and preventable readmissions to hospitals within 30 days after discharge are driving excessive healthcare cost for patients and providers. Reducing unplanned 30-day readmissions is an opportunity for many hospitals to improve quality of care and reduce the penalty stipulated by the Affordable Care Act.
**Research Objectives**

1. Determine risk-standardized 30-day unplanned readmission rate by hospital, hospital-wide, and by selected specialty cohort.
2. Develop a 30-day unplanned readmission prediction model for the nine Cleveland Clinic hospitals in NE Ohio.
3. Analyze time from discharge to next admission to identify where there are high readmission rates and patients that stay out of the hospital long enough for the healthcare provider to do something about it in an outpatient setting.
4. Stratify patient population to surface meaningful patient characteristics across various readmission risk sectors.

**Methodology**

The statistical models and other analyses will be based on prior 1 to 3 year’s admissions data. Multilevel logistic regression will be used for Objectives 1 and 2. For objective 4, data mining will be used to segment the patient population.

**Potential Impact**

Improve quality of patient care to reduce unnecessary 30-day readmissions, healthcare utilizations, and cost of care.
Project Update

The previous readmission study done for BayCare laid the foundation for exploring readmissions at Cleveland Clinic. The latest findings for Cleveland Clinic are given below.

- Readmission risk predictors

<table>
<thead>
<tr>
<th>Category</th>
<th>Independent Variables</th>
</tr>
</thead>
<tbody>
<tr>
<td>Demographics</td>
<td>Marital status</td>
</tr>
<tr>
<td></td>
<td>Payer class</td>
</tr>
<tr>
<td>Historical Utilization</td>
<td>Prior admissions within last 3 months</td>
</tr>
<tr>
<td></td>
<td>Prior ED visits within last 6 months</td>
</tr>
<tr>
<td></td>
<td>Charlson Comorbidity Index</td>
</tr>
<tr>
<td></td>
<td>Days since last discharge</td>
</tr>
<tr>
<td>Current Utilization</td>
<td>Admitting hospital</td>
</tr>
<tr>
<td></td>
<td>Length of stay</td>
</tr>
<tr>
<td></td>
<td>Discharge disposition</td>
</tr>
<tr>
<td></td>
<td>Discharge date’s season</td>
</tr>
<tr>
<td></td>
<td>Behavioral flag nonsubstance</td>
</tr>
<tr>
<td></td>
<td>Days to next outpatient visit</td>
</tr>
</tbody>
</table>

- Overall readmission risk-prediction model’s C-statistics:
  - Logistic Regression: 0.7540
  - Multilevel Logistic Regression: 0.7750

- For all adult patients who were readmitted within 30 days:
  - 25% were readmitted within 1 week of discharge
  - 75% were readmitted within 3 weeks of discharge

- Patients discharged to a skilled nursing facility tend to be readmitted sooner than those discharged to home or home care, except for patients diagnosed with Anemia.

- As with the BayCare system, the number of days to a patient’s next readmission did not appear to depend on his or her CCS Level 2 diagnosis.
**Population Health Management Modeling to Support Accountable Care Delivery (Pilot: OurHealth)**

**Research Team**

**Faculty**
Steve Witz, Regenstrief Center for Healthcare Engineering, Purdue University

**Staff**
PI: Ken Musselman, RCHE, Purdue University
Ping Huang, RCHE, Purdue University
Kit Klutzke, RCHE, Purdue University

**Students**
Hambisa Keno, Industrial Engineering

**Healthcare Partner**
OurHealth

**Research Direction**

**Competencies**
Data analysis
Modeling
Stratification
Interactive data exploration
Cluster analysis

**Research-to-Impact Phase C** (Single-site pilot study and evaluation)

**Research Timeline**
March 2014–December 2015

**Project Summary**

**Healthcare Problem**
RCHE is collaborating with OurHealth to develop a decision-support capability to improve the health of company communities to improve their quality of care and cost-effectiveness. This research seeks to support this overall initiative by performing clinical analytics to identify medical-management strategies that will improve population health in targeted areas through the use of a medical-management decision-support tool. The process will leverage OurHealth’s clinical knowledge with claims and biometric information coming from OurHealth’s patient population to identify those patients whose outcomes will benefit the most from intervention efforts and better informed choices.
**Research Objectives**

1. Evaluate data availability and technology opportunities associated with OurHealth functioning as an information source for the operation of the Population Health Model.

2. Verify the Data Input Processor accurately captures insurer input.

3. Establish appropriate health metrics to support the stratification of OurHealth’s patient population.

4. Investigate various approaches to patient-risk stratification that will improve OurHealth’s ability to identify and prioritize sound, evidence-based medical-management strategies.

5. Evaluate the model’s effectiveness in providing actionable steps for providers to pursue better accountable-care delivery.

6. Disseminate the research findings to OurHealth and other appropriate organizations.

**Methodology**

Upload and verify the transfer of the data elements from the OurHealth system to drive decision-support methodologies, filtering the elements as appropriate. Parameterize the models to best address the environment, and then work with OurHealth to understand the appropriateness and usefulness of the models in determining targeted medical-management strategies for this population.

**Potential Impact**

To improve accountable-care delivery effectiveness through the improved selection and adoption of clinic-specific management.

**Project Update**

Did a comparative analysis (using OurHealth’s biometric data) of three methodologies: score, appraise, and compare. The table on the next page provides a summary of the findings. The compare method showed a number of significant advantages, including ability to scale (number of criteria), addressing missing data, displaying more discrimination power, and not requiring consensus-building.
The research team is now working with OurHealth to advance three initiatives:

1. Combine claims data with biometric data to assess OurHealth’s patient population across a wider array of health factors.

2. Explore various means of extracting patient outliers.

3. Examine the ability of the compare methodology to go beyond relative comparisons to absolute.

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Methodology</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Score</td>
</tr>
<tr>
<td>Addresses simultaneous, multiple criteria</td>
<td>✓</td>
</tr>
<tr>
<td>Handles dissimilar criterion scales</td>
<td>✓</td>
</tr>
<tr>
<td>Is scalable (number of criteria)</td>
<td>✓</td>
</tr>
<tr>
<td>Is scalable (population size)</td>
<td>✓</td>
</tr>
<tr>
<td>Is scalable (across populations)</td>
<td>✓</td>
</tr>
<tr>
<td>Allows for non-linearity</td>
<td>✓</td>
</tr>
<tr>
<td>Allows for missing data</td>
<td>✓</td>
</tr>
<tr>
<td>Has discrimination power</td>
<td>✓</td>
</tr>
<tr>
<td>Handles nominal criteria</td>
<td>✓</td>
</tr>
<tr>
<td>Does not require subject matter expert (or consensus building)</td>
<td></td>
</tr>
</tbody>
</table>
Population-Health Management Modeling to Support Accountable-Care Delivery (Pilot: St. Vincent Health)

Research Team

Faculty
PI: Steve Witz, Regenstrief Center for Healthcare Engineering, Purdue University
Nan Kong, Biomedical Engineering, Purdue University

Staff
Kit Klutzke, RCHE, Purdue University

Students
Mina Ostavari, Industrial Engineering

Healthcare Partners
St. Vincent Health

Research Direction

Competencies
Data analysis
Modeling

Research-to-Impact
Phase C (Single-site pilot study and evaluation)

Research Timeline
March 2014–December 2015

Project Summary

Healthcare Problem
RCHE is collaborating with St. Vincent Health to improve the quality of care and cost-effectiveness for populations. This research defines populations as individuals who are eligible to receive health benefits through their employer’s health-benefits plan. The participating employers have self-funded health-benefits plans and have established contracts for work-site clinics and consultation for population-health management. This research analyzes patterns of healthcare utilization, as represented by healthcare claims data, and identifies medical-management strategies that will improve population health. The research will monitor the implementation of selected medical-management strategies and use patient outcomes and the employer’s paid claims as metrics for population-health management effectiveness.
**Research Objectives**

*This research will:*

- Develop a longitudinal claims data base and supportive information to identify population-health conditions and healthcare utilization.
- Identify population-health management opportunities to improve healthcare quality and cost.
- Evaluate the effectiveness of population-health management strategies.
- Disseminate findings for generalization when appropriate to other populations to enhance population-health management knowledge and practices.

**Methodology**

Statistical analyses

**Potential Impact**

To improve population-health management that improves quality and cost through evidence-based collaborations among employers and providers.

**Project Update**

A claims data base has been constructed and is being analyzed. The patterns of utilization by members of the population have been assessed to provide detailed analyses of utilization by population members characterized by demographic and condition variables.

RCHE and St. Vincent clinicians are grouping population-health management strategies in categories of services to be delivered at work-site clinics, the larger integrated delivery system at St. Vincent Health, and strategies to reduce the costs of high volume services to the employer.

Employers are starting the process of reviewing population-health management plans. This review will identify the first series of population-health management strategies to be implemented.
Affecting Cancer Together

Research Team

Faculty PI: Cleveland Shields, Human Development and Family Studies; Purdue University

Healthcare Partner Community Cancer Health Advocacy Groups in Indiana and Lay Educators

Research Direction

Competencies Community-centered research
Statistical analyses
Lay community involvement in education and prevention

Research-to-Impact Phase Phase D (Multisite pilot study and evaluation)

Research Timeline January 2011–January 2015

Project Summary

Healthcare Problem The reduction in cancer morbidity and mortality is dependent upon effective public programs for cancer awareness, prevention, and screening. Limited public knowledge and ineffective messaging, particularly for underserved communities, have led to disparities in cancer incident rates among certain population groups.

Research Objectives

1. Prevention of cancer and other chronic diseases in Indiana through awareness and education, providing a bridge to health resources and services, as well as developing health leaders, lay health educators, and health motivators in the community.

2. Improve health outcomes for all, including underserved populations.

Methodology Nontraditional healthcare settings in the community are utilized to promote awareness, educate about, motivate, and encourage prevention and early detection of cancer and chronic diseases. The focus is on integrating the community’s input and feedback into ACTion.

Potential Impact The evaluation project has been completed. We interviewed 55 barbers and 165 barbershop clients. We found that the more highly educated barbers and married barbers carried on more conversations about health and cancer prevention than did less educated unmarried barbers. Their clientele also were less knowledgeable.
We have two publications under review, one has received a revise and resubmit.


See-What-I-Do: Increasing Mentor and Trainee Sense of Co-Presence in Trauma Surgeries with the STAR Platform

Research Team

Faculty
PI: Juan Wachs, Industrial Engineering, Purdue University
Voicu Popescu, Computer Science, Purdue University
Brian Mullis, MD, Surgery, Indiana University School of Medicine
Gerry Gomez, MD, Surgery, Indiana University School of Medicine
Sherri Marley, Indiana University School of Nursing

Students
Dan Anderssen, Industrial Engineering, Purdue University
Sthitapragyan Parida, Electrical and Computer Engineering, Purdue University

Healthcare Partners
Eskenazi Health
Fairbanks Hall Simulation Center
Large Animal Research Center

Research Direction

Competencies
Gesture recognition
Telementoring
Augmented reality
Simulation

Research-to-Impact
Phase D (Multisite pilot study and evaluation)

Research Timeline
2014–2016

Project Summary

Healthcare Problem
Optimal trauma treatment integrates different surgical skills that are not always available in military field hospitals. Telementoring can provide missing expertise; yet, current systems require the trainee to frequently focus on a nearby telestrator, fail to illustrate the next surgical steps, and give the mentor an incomplete picture of the ongoing surgery.

The development of the System for Telementoring with Augmented Reality (STAR) will address these shortcomings.

Research Objectives
1. Develop and assess a transparent-display augmented reality system that enhances trainee’s natural view of the surgical field by illustrating current and next surgical steps.
2. Develop and assess a patient-size interaction platform where the mentor uses gestures to mark, annotate, and zoom in on anatomic regions over a projected image.


4. Validate the refined STAR with surgery residents in hemorrhage-control procedures within a damage-control laparotomy on live porcine models in a simulated austere environment.

Methodology

Methodologies used for each of the corresponding objectives above are given below:

- 3-D scene acquisition, camera calibration, color-to-depth registration, head tracking, 3-D rendering, parameterized simulation, and visualization of simulation data.

- Hidden Markov Models, Kinect-based tracking library, and Wizard of Oz prototyping.

- Trauma Man Cric simulator and direct corpsmen and/or paramedics to perform a surgical cric, using direct observation and video review to evaluate with the Prehospital Trauma Life Support (PHTLS) competency checklist.

- Hemorrhage-source identification and control through direct observation and video review evaluated by trauma surgical faculty of a Level 1 trauma center.

Potential Impact

STAR will increase access to subspecialty surgical expertise, help refresh skills of surgeons returning from temporary deployment, and decrease complications rates for recent medical-school graduates in deployment.

Project Update

Preliminary indications are that STAR allows trainees to follow some mentor instructions more accurately. The main finding is that focus shifts were greatly reduced when using STAR, as opposed to the conventional system. This is a reasonable result, given that a participant in the conventional condition is required to shift focus to access the instruction, while in the STAR condition, accessing the instruction does not require shifting focus. Based on the completion of the initial experiment, we can state that, on average, the placement error was considerably smaller when using the augmented reality system than when using a separate screen. The tablet provides precise feedback as to where a pointer should be placed and the participant leverages this feedback to minimize placement error.
Improving Medication Adherence through Practitioner and Patient Health Literacy Education

Research Team
Faculty
Kim Plake, Pharmacy, Purdue University

Healthcare Partner
Wishard Health Services

Research Direction
Competencies
Health literacy assessment
Health literacy intervention

Research-to-Impact Phase
Phase C (Single-site pilot study and evaluation)

Research Timeline
June 2011–December 2015

Project Summary
Healthcare Problem
Treatment adherence after cardiovascular events has been cited as being as low as 54 percent after one year. Functional health literacy has been shown in a number of studies to affect a patient’s medication adherence. Prior to an Institute of Medicine report in 2004, little health literacy education was provided in professional schools, leaving many nurses and pharmacists ill-equipped to work with low health literacy populations.

Research Objectives
This project seeks to develop and implement a health literacy education program to assist providers in working with patients of varying levels of health literacy. The program will also enable clinicians to develop their own patient education approaches and tools. Long term, the program objectives are to:
1. Integrate health literacy tools into contemporary practice;
2. Improve adherence to antihypertensives and cholesterol-lowering medications; and
3. Improve clinical outcomes in patients with low health literacy.

Methodology
A comprehensive list of gaps and unmet needs was established through a review of the literature and in consultation with various practitioners. An in-person session will be developed with material to address these gaps. A website will also be developed to serve as an additional resource after the presentations.
The program will be assessed using a decision-oriented logic model type developed by the Kellogg Foundation and recommended for complex program designs.

**Potential Impact**

Patients who are more health literate are more able to understand their condition, participate in managing it, and adhere to their treatment regimen, thereby improving their health.

**Project Update**

This project was jointly funded by the Regenstrief Center for Healthcare Engineering and Pfizer. It builds on the faculty members’ existing expertise in patient health literacy and health literacy education developed through several previous projects. RCHE provided seed funding for one such project and others have been externally funded.

Project funds enabled the purchase an automated refill reminder system. This system calls patients to remind them to get their prescriptions refilled. It is automated and allows the patient to choose to refill their prescription when on the call.

There were multiple delays with this project due to delays in implementing the refill reminder system, as well as limited engagement from the providers in the educational sessions. The analysis of proportion of days covered is continuing as it was a longitudinal study. The baseline Proportion of Days Covered (PDC) has been calculated and the 3 month data point will be analyzed next. We have 6 and 12 month data points as well. The primary evaluation will be evaluating the refill reminder system.
Comparative Effectiveness of Different Implementations of the Patient-Centered Medical Home Model in Rural Indiana

Research Team
Faculty
- PI: Cleveland Shields, Human Development and Family Studies, Purdue University
- Elliot Friedman, Human Development and Family Studies, Purdue University
- Stewart Chang Alexander, Consumer Science, Purdue University

Staff
- Poching DeLaurentis, Regenstrief Center for Healthcare Engineering, Purdue University

Students
- Phanlada Chatha-Hill, Health and Kinesiology
- Lindsay Fuzzell, Human Development and Family Studies

Healthcare Partner
- Indiana Rural Health Association (IRHA)

Research Direction
Competencies
- Comparative effectiveness
- Quasi-experimental design

Research-to-Impact Phase
- Phase B (Research and model development)

Research Timeline
- May 2015–December 2015

Project Summary
Healthcare Problem
- This project supports the community work required to prepare a Patient Centered Outcomes Research Institute (PCORI) application. PCORI applications and contracts are different from NIH and NSF applications in that they require extensive involvement of the community in which the research is planned.

In this case, community partners include patients, physicians, and other providers, administrators, and IRHA staff. We will need to engage these stakeholders in meaningful conversations that broaden our understanding of rural health concerns, help us develop appropriate outcome and process measures, and help us adapt the Patient Centered Medical Home (PCMH) model appropriately in the rural study sites.
**Research Objectives**

1. Conduct a comparative effectiveness study using a quasi-experimental design comparing different models of PCMH in rural IRHA sites.

2. Work with stakeholders to identify sites and define PCMH models for them. Examine whether and how to include suburban or urban sites for comparison.

**Methodology**

PCORI methodology standards require us to develop interventions, outcomes, processes, and all research plans in collaboration with community partners. The work is focused on comparative-effectiveness research in which two or more treatments with known efficacy are compared. The idea is not only to find out what works best but also under what circumstances and with whom (i.e., to examine the heterogeneity of treatment effects).

**Potential Impact**

IRHA consists of 30 hospitals and has a presence in virtually every rural county in Indiana. Writing and submitting this PCORI application represents a unique opportunity for RCHE and for Health and Human Sciences at Purdue to develop working relationships with rural healthcare systems. As a land-grant university with a mission to serve the needs of the whole state, we hope to build lasting partnerships between RCHE and IRHA.

**Project Update**

This project has just now been initiated.
Wellness-Coaching Impact on Employee-Health Outcomes

Research Team

Faculty
PI: Bart Collins, Communication, Purdue University

Students
Heather Fedesco, Communication, Purdue University
Wan Jiang, Science, Purdue University
Yao Tang, Statistics, Purdue University

Healthcare Partners
Paradigm

Research Direction

Competencies
Data Mining
Health Communication
Prediction and Forecasting
Risk Stratification

Research-to-Impact
Phase A (Healthcare system evaluation with stakeholder input)

Research Timeline
May 2014-May 2015

Project Summary

Research Objectives
The primary objective of this project is to identify outcomes associated with employee health coaching initiatives on a variety of potential outcomes, including health claims, health-risk status, and preventative health utilization. Secondary objectives include examination of demographic, psychosocial, and health factors associated with variation in the effectiveness of coaching.

Methodology
Two primary data sets and methodologies are being implemented to reach these objectives. First, an analysis of an existing de-identified data set of longitudinal health claims and risk information (MEDai-based) associated with a variety of regional employers is being analyzed to evaluate outcomes of approximately 500 wellness coached employees with a propensity scored matched set of uncoached employees. Second, coached individuals are participating in an online survey to evaluate additional psychosocial and self-reported outcomes associated with coaching participation. The survey focuses on wellness-coaching communication characteristics and their impact on employee-health self-management processes.
Potential Impact

Employers are increasingly investing in wellness and prevention-oriented initiatives. However, short- and long-term impact of such interventions needs investigation. Additionally, this project should help profile employee characteristics that respond best to this type of health intervention to improve targeting appropriate employees in the future.

Project Update

IRB approval for project was granted in November 2014. De-identified MEDai data was received in December 2014, representing 40 months of MEDai health-claim summaries and risk information for approximately 20,000 covered lives. Approximately 500 individuals received wellness-coaching interventions during that time period. Propensity score matched individuals were compared with the wellness-treatment group. Results of the analysis identified that wellness-coached individuals were more engaged with formal healthcare-delivery services than similar uncoached individuals. Analyses suggest that this increase in utilization was best explained by increased engagement with preventative health services and was relatively consistent across individuals addressing a wide range of health and wellness issues. Survey data from the coached population was collected in April, and results of this component are currently being analyzed. This analysis of the secondary data sets formed the basis of Heather Fedesco’s successfully defended dissertation in May from the Brian Lamb School of Communication, entitled: “Employee wellness coaching as an interpersonal communication intervention: Exploring intervention effects on healthcare costs, risks, and behaviors.”
Bundled Payments

Research Team

Faculty
PI: Steve Witz, Regenstrief Center for Healthcare Engineering, Purdue University
Rebecca Doerge, Statistics, Purdue University

Staff
Zhiyi Tian, Regenstrief Center for Healthcare Engineering, Purdue University

Student
Simeng Qu, Statistics, Purdue University

Healthcare Partners
Cooperative Managed Care Services, LLC

Research Direction

Competencies
Data mining
Statistical analysis

Research-to-Impact
Phase B (Research and model development)

Research Timeline
November 2014–May 2016

Project Summary

Healthcare Problem
Fee-for-service healthcare reimbursement is alleged to provide financial incentives for healthcare providers to deliver redundant and/or unnecessary patient services. New forms of reimbursement collectively referred to as value-based purchasing seek to change these inherent financial incentives by prospectively limiting the amount of reimbursement to providers. These policies shift financial risk from third-party payors to healthcare providers and are intended to simultaneously improve patient outcomes and cost-effectiveness.

Healthcare providers have not developed actuarial methodologies to assess and mitigate the new financial risks imposed by value-based purchasing. Providers’ reluctance to accept risk without these management capabilities deters the ability to assess the purported merits of value-based purchasing.

One form of value-based purchasing is bundled payment reimbursement. Bundled payments combine all services for a defined episode of care into a single amount of payment. Providers may place bids for bundled payment services to gain market share. Providers are financially at risk for the patient care provided under these contractual awards.
Research Objectives

Develop and validate analytic methodologies to assist healthcare providers to assess and mitigate financial risk inherent in bundled payment.

- Decompose the financial variance among episodes of care for a given case type into component elements.
- Support providers’ review and re-engineering of the care delivery process to reduce the variation in elements of care, while improving quality and cost management in the care episode.
- Provide quantitative methodologies to establish bid prices for care episodes in bundled payment contracting.

Methodology

Use point estimate to estimate the mean and variance of the cost of a care episode. Total knee arthroplasty (TKA) will be the initial care episode analyzed. Episode costs will be decomposed into three components: 30 days before hospitalization, the index hospital admission, and 90 days post-acute care. The contribution of each of the three components to the total episode variance will be determined. Within each component, identify the chargeable items that contribute to total variance.

Replicate this analytic approach on hip arthroplasty episodes to determine the feasibility of this approach on episodes other than TKA.

Provide analyses of financial risk and options to mitigate risk to healthcare providers to support their determination of care-delivery profiles, associated financial risk, and contracting terms to establish episode bids.

Potential Impact

Help to reduce healthcare cost, while improving quality of care.
Project Update

Considering the impact and potential for quality and efficiency improvement, total knee replacement (TKA) is chosen for initial condition to study for bundle payment. Three years of medical-claim data has been received from Cooperative Managed Care Services (CMCS) for patients with St. Vincent Health Care Management Organization (CMO) health plan.

Index TKA procedures have been identified by a series of CPT codes, ICD9 procedure codes, and DRG codes. In the three-year period, 31 patients had at least one total knee replacement procedure, and three of them had two procedures, which resulted in 34 index procedures in total. Each of the index procedures triggered an episode and was counted as an independent episode for analysis. From the 34 episodes, 22 patients were females and 12 patients were males. Patient age at time of procedure ranged from 44 to 70 years old.
We define an episode as an index procedure, including 30 days prior and 90 days post. Currently, we evaluate the total charge during the entire episode. The total charge is the sum of four components: Service Paid Amount, Copay Amount, Deductible Amount and Coinsurance Amount. The total charge varies dramatically from episode to episode, and ranges from $6,507 to $72,424, with a mean of $30,198.
To find the source of variation, we study the association between total charge and various factors, such as patient age, patient gender, hospital length of stay (LOS) for total knee replacement, hospital discharge disposition, and patient Charlson Comorbidity score. Among those factors evaluated, we find that longer length of stay is statistically significant with higher total charge.

### Table: LOS for TKA vs Total Charge

<table>
<thead>
<tr>
<th>LOS for TKA</th>
<th>N</th>
<th>Total Charge</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Mean</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>30785.7400</td>
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<tr>
<td>2</td>
<td>8</td>
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<td>33303.2133</td>
</tr>
<tr>
<td>5</td>
<td>2</td>
<td>52084.5700</td>
</tr>
</tbody>
</table>

### Distribution of total_charge

![Distribution of total_charge](image)
The analyses for TKAs continued with a review and editing of patient outliers. Eight patients with TKAs were eliminated from the analyses due to atypical care. The elimination of these patients from the analyses did not significantly change the mean-episode charges. It did, however, reduce variation in total episode charges as indicated by a reduction in the coefficient of variation from .382 to .251.

Total episode cost was divided into components of the episode: preadmission, admission and postadmission. Mean total charges for preadmission represented 4% and postadmission was 18% of the total average episode charges. The admission component represented 78% and included hospital charges at 64% and professional charges at 14% of the average total episode charge. The hospital charges for the admission component and the posthospitalization charges represented the largest variance in charges. These two components of care have been selected for further analyses, and data collection to enable this expanded analyses is underway.

RCHE is also replicating the analyses of TKA episodes with a sample of patients who received a total hip replacement. The intent is to test the generalizability of findings in a second cohort of patients. As anticipated, the mean charges for hip replacement differ significantly from the TKA episode charges. We have found similar findings with regard to the effect of editing patients who received atypical care on significantly reducing variance in the total episode charge and the relative percent of total episode charges generated during the preadmission, admission and postadmission components. Two hip patients were found to have postdischarge charges that were significantly higher than other patients in their cohort. Both of these patients required rehospitalization for hip revisions, which indicates an opportunity to study these patients further for opportunities to reduce the need for revision procedures.

This bundled-payment analysis will include a review of the data with the hospital and orthopedic surgeons to evaluate research findings and additional research directions.
Development of Physiological Monitor Databases

Research Team

Faculty
Elisa Bertino, Computer Science, Purdue University

Staff
PI: Md Munirul Haque, Regenstrief Center for Healthcare Engineering, Purdue University
Rich Zink, Regenstrief Center for Healthcare Engineering
Peter Baker, CyberCenter, Purdue University

Healthcare Partners
Monitor Manufacturers:
• GE Healthcare
• Philips Healthcare
• Draeger Medical
• Covidien
• Spacelabs Healthcare

Healthcare Providers:
• To be determined

Dissemination Partner:
• Association for Advancement of Medical Instrumentation (AAMI)

Research Direction

Competencies
Databases
Data visualization
Big data analytics

Research-to-Impact
Phase A (Healthcare system evaluation with stakeholder input)

Research Timeline
November 2014–June 2016

Project Summary

Healthcare Problem
The Emergency Care Research Institute (ECRI) identified alarm hazards as the number-one hazard for 2014. Alarm fatigue continues to be a problem for nurses in the clinical environment, but unfortunately there is no database of physiological parameter alarm records. As a result, hospitals are failing to take any meaningful measure to reduce the number of alarms being generated by different monitor devices. Finally, the parameters monitored by these devices are not stored in a continuous fashion. The longitudinal historical records of these parameter values can provide a novel analytical domain for researchers and vendors.
Research Objectives

1. Document agreed-upon terms for physiological parameters.
2. Document default values, soft limits, and hard limits (where applicable) of physiological parameters categorized by different vendors.
3. Document default values, soft limits, and hard limits (where applicable) of physiological parameters categorized by different profiles and hospitals.
4. Design and develop a database for physiological-parameter alarms.
5. Develop the analytical and visualization tool based on the collected alarms.
6. Finally, start building a 24/7 database based on selected physiological parameters.
7. Establish an evidence-based community of practice.

Methodology

We will be working with the Association for Advancement of Medical Instrumentation (AAMI), vendors, hospitals, and other teams to achieve objectives 1 through 4. The Regenstrief Center for Healthcare Engineering (RCHE) at Purdue will develop the Physiological Parameter Informatics (PPI) System (Objective 4 and 5) to make it easy to analyze physiological-parameter alarm data and best practices. The tool allows for physiological-parameter alarm data to be readily accessible, meaningful, and actionable. The participating hospitals form a virtual community that exchanges information, shares analysis results, and collaborates on ways to improve the tool and patient safety. The scientific collaboration platform, www.CatalyzeCare.org, is leveraged as the collaboration space for providers and researchers. RCHE provides the collaboration space, supports the community by hosting regular community meetings, and provides technical support for using CatalyzeCare. The web-based application for analyzing physiological-parameter alarm data will be deployed in CatalyzeCare.

Potential Impact

Improve safety, efficacy, and efficiency in managing physiological monitor alarm data. This also includes reducing alert fatigue. The analysis enabled through this project helps hospitals identify areas for improvement and education in their physiological monitor alarm-management process. The community of practice that will be growing through this project will provide professional networking and support for healthcare providers focused on this issue, and help them disseminate important results to their colleagues for even greater improvement. The analysis of a 24/7 physiological monitor parameter database may lead to more customized, patient-based alarm management.

Project Update

A high-level project plan has been developed identifying three systems to be developed. Phase 1 is the creation of a system to store and analyze vendor and provider default settings. Phase 2 is the creation of a system to store and analyze monitor alarms, and
Phase 3 is the creation of a system to store and analyze continuous monitor data. Initial data for vendor and provider defaults have been captured and will be used in the development of the initial Phase 1 system. Programming on the system is expected to begin in May 2015. For Phases 2 and 3, AAMI is coordinating additional meetings with monitor vendors to understand what alarm and continuous data is available as inputs to the systems. The vendor meetings are planned for completion by June 1, 2015. Following the vendor meetings, AAMI will coordinate meetings with providers to better understand the issues they face and their analytic needs in this space. A student researcher has been identified to work on the project, beginning Fall 2015.
Transitions in Care Pilot: Evaluate the Impact of Electronic Communications

Research Team

Faculty
Co-PI: W. Bart Collins, Communication, Purdue University
Co-PI: Steve Witz, Regenstrief Center for Healthcare Engineering, Purdue University
Yuehwern Yih, Industrial Engineering, Purdue University

Students
Shan Xie, Industrial Engineering
India Bergeland, DURI Scholar, Industrial Engineering
Brad Harris, Industrial Engineering
Lindsey DiTirro, Communication
Ryan Cummings, Communication

Healthcare Partner
Michiana Health Information Network (MHIN)

Research Direction

Competencies
Health IT evaluation
Workflow analysis
Statistical analysis

Research-to-Impact
Phase B (Research and model development)

Research Timeline
June 2014–August 2015

Project Summary

Introduction
This research was initiated to address difficulties in patient-care transitions identified in our study of critical-access hospitals, reported in the literature, and by the Office of the National Coordinator for Health Information (ONCHIT). A common issue in the quality of transitions of care is adequacy of communications pertaining to patients’ conditions and care plan. This research is divided into a systems analysis of transitions of care communication, and the perceptions of care providers relative to using direct messaging.

Healthcare Problem
Effective patient transitions require communication among healthcare providers pertaining to the patient’s condition and treatment plan. The hospital-discharge summary and referral request are common communication formats for the exchange of this information. Previously reported research documents indicated that these types of
communication may not occur in a timely manner or may be missing critical information. These communication limitations are associated with ineffective care transitions and care coordination.

Research Objectives

1. Assess the value of electronic communications at improving patients’ continuity of care during care transitions.
2. Identify opportunities to use electronic communications most effectively within current provider communication processes.
3. Improve care-communication timeliness and content required for patient continuity of care.

Methodology

The analyses are organized in four sections. First, de-identified patient data are analyzed to identify the number and types of care transitions within a 30-day posthospital discharge. Second, semistructured interviews are conducted with hospitals and skilled nursing facilities (SNFs) to collect data to evaluate the information transfer process pre- and postimplementation of electronic communications in terms of content, format, timeliness, cost, and security. Time-stamp data are analyzed to evaluate the usage of the system and identify potential system breakdown and bottleneck. Third, patient outcomes, such as readmission, ED visit, length of stay, etc., are analyzed to evaluate the impact of the interventions. Fourth, provider attitudes and perceptions of direct-messaging care transitions, and meaningful use will be measured through survey methods in collaboration with MHIN.

Potential Impact

The improved communication made possible through this project is expected to result in:

1. Increased provider satisfaction with the availability and quality of clinical information.
2. Improved patient outcomes (e.g., a reduction of hospital readmissions among patients discharged to a SNF or LTPAC facility).
Project Update

IRB approvals have been granted for existing data, interview, and survey. Data collection for survey began May 2015. Ten interviews were conducted with hospitals and skilled nursing facilities. The referral process pre- and postimplementation of electronic communications was assessed. The workflow analysis was categorized into SNFs that have clinical liaison and those that do not have clinical liaison. The results for the first category are included here. The highlighted boxes indicate the differences occurred in the process.
For major tasks performed by a social worker assistant and clinical liaisons, the time that it takes to finish each step was estimated based on the interview data and compared for pre- and post-implementation.

*The total length of the bar indicates maximum time, yellow line indicates minimum time and red line indicates average time.*
The benefits of having electronic communications are summarized as follows:

1. Saves time for hospital staff (e.g., printing time, faxing time, and searching for a fax machine) and clinical liaisons from SNFs.
2. Information is readily accessible. Clinical liaisons are less dependent on social workers and their assistants.
3. Social worker can spend more time with patients without being interrupted by others who seek more information.
4. Information is available to multiple people at the facility.
5. Eco friendly—less paper printing
6. More secure than fax by reducing the possibilities of the wrong person picking up the fax, loss of information, and potential breach of patient-information privacy.

In addition to the benefits, the following potential improvements to the current system would make the electronic communications more effective.

1. Incorporate patient name to the subject line of direct messaging.
2. Integrate face sheet and 72-hour report to the electronic referral template or save them as electronic documents that could be attached to direct messaging.
3. Only include the most recent medication list, and improve the format of the electronic referral report.
4. Enforce callback information be entered rather than relying on the sender to include the information.
5. Improve the reliability of the system.
6. Make sure everyone fully understands the functionality of the tools.
7. Provide consistent training and support.
8. Conduct regular user evaluation, and encourage feedback and critiques.
Drug-Limit Library Database and Research

Research Team

Faculty/Staff
PI: Poching DeLaurentis, Regenstrief Center for Healthcare Engineering, Purdue University
Rich Zink, RCHE, Purdue University
Yuehwern Yih, Industrial Engineering, Purdue University

Student
Kang-Yu Hsu, Industrial Engineering

Healthcare Partners
TBD

Research Direction

Competencies
Database
Data mining
Pattern and clustering analysis

Research-to-Impact
Phase B (Research and model development)

Research Timeline
May 2015–May 2016

Project Summary

Healthcare Problem
The infusion drug-alert data and knowledge sharing within this IPI System-forged community of practice, along with the various reporting tools on the system, provide clinicians with in-depth information on medication infusions and their alerts. Many IPI System users, researchers, and organizations (e.g., Association for the Advancement of Medical Instrumentation, AAMI) see the value in creating a database of drug-limit libraries (DLLs) in addition to the alert database already in place.

Research Objectives
This project consists of two phases. Phase I aims to construct a DLL database of IPI System users’ drug limits. Phase II aims to utilize this database to understand the setting of drug limits and other relevant questions.

1. Construction of a searchable drug-limit library/database and interactive display
   a. Identify and define what will be displayed in a DLL database, based on user (customer) requirements as basic view
   b. Identify the fields in a drug-limit library to be extracted or combined and methods
      ▪ How to resolve format differences of DLLs from various pump vendors?
c. Design the dynamic drug-limit library/database, display format, and functionality (tools)
d. Implementation of the drug-limit library/database and interactive display
e. Continuous improvement of the database based on user feedback

2. Analysis of the drug limits
   a. Compare and contrast selected drug limits in the alert data vs nonalert data
   b. Study how drug limits evolve/converge over time
   c. Investigate the factors involved in setting drug limits
      Some specific questions may be:
      • Which drugs are reviewed the most?
      • Is there a convergence in limits for the community?
      • Do those that access the database make more changes?
      • What do the users view?
      • Do those that access the database more often decrease the number of alerts per device? This would be a cross-database analysis, which requires data from the IPI database.
      • How are the alert patterns of different drug limits set for a particular drug? Compare those in the same facility and in different facilities.

Methodology

The construction of the DLL database will utilize database programming and visualization technologies and be based on HUBzero. Statistics, time-series analysis, pattern mining and machine learning techniques will be applied to study drug limits across hospitals, care units, drug types, and so on.

Potential Impact

A searchable drug-limit library database will allow clinicians and researchers to quickly find the limits hospitals set for a particular drug, compare how drug limits differ from one hospital or care unit to another, and how the limits evolved over time. The DLL database can also serve as the basis of what may later become a commercial-grade product and be used as a model for other similar applications. The analysis of drug limits across hospitals, care units, and drug types will enable the researchers to study the characteristics of various drug limits, how the IPI community’s knowledge diffuses and what its potential impact on clinical practice may be over time.
**Project Update**

The team has already received some user requested database specifications, which are serving as the first set of system requirements of this DLL database. The graduate research assistant has started learning the HUBZero technologies. A project kickoff meeting took place on May 6, 2015, with the RCHE Co-PIs, Purdue engineering faculty, and graduate research assistant attending.
Drug-Limit Library Update Process

Research Team

Faculty/Staff
Poching DeLaurentis, Regenstrief Center for Healthcare Engineering, Purdue University
Rich Zink, RCHE, Purdue University
Yuval Bitan, Cognitive Technologies Laboratory, Chicago, IL

Student
Ana Isabel De la Hoz Armenta, Industrial Engineering, Universidad Nacional in Medellín

Healthcare Partners
Eskenazi Health

Research Direction

Competencies
Human factors
Data mining
Pattern and clustering analysis
Data visualization

Research-to-Impact
Phase B (Research and model development)

Research Timeline
March 2015–December 2015

Project Summary

Healthcare Problem
Smart-infusion pumps are one of many types of medical devices that work in an information technology (IT) networked clinical environment. These pumps typically utilize a drug-limit library or guardrails to set limits on the dosage or rate of drug infusions. From time to time, changes or updates may be made to the drug-limit library, and they are done via wireless network in most modern facilities. Therefore, it becomes a priority to ensure the interoperability of these modern medical devices and information-network technologies for it is a crucial part of safe medical-care delivery. However, not much is known whether designed interoperability works as well in practice.
Research Objectives

The main objectives of this project are to understand and evaluate the current infusion-pump update process, identify any best practices, and improve the reliability of the process. Our research questions include:

- What is the current infusion-pump updating process?
- Why may it take several weeks to update all the pumps in a facility?
- What are the barriers to efficient and effective pump updates?
- How can we improve the technology and human workflow to make the pump updates more reliable?
- What can we learn from the drug limit library update process to inform the future of medical device interoperability in the healthcare working environment?

Methodology

We start by analyzing the version of library or data-set field in the IPI alert data (of a few hospitals) and how they change over time. We will work closely with clinicians and possibly vendors to understand the pump-update workflows of technology and human aspects.

Potential Impact

The results of this project may shed light on the broader question regarding the design and implementation of interoperability of future medical devices.

Project Update

We have started analyzing drug-limit library update history based on drug-alert data in our IPI database. Some conversations have taken place between the researchers, a pump vendor (Carefusion), and Eskenazi Health, regarding the general limit library-updating process and the overlapping of drug-limit libraries we discovered. Initial analysis has also begun to capture the characteristics of the pump-updating process, such as the length of extended use of an inactive library version, frequency of updates in a facility, etc. In the meantime, we are refining the research questions for this project, as well as searching for potential publication outlets and conferences for this work. The data-sharing agreement between Purdue and Yuval Bitan has been established and executed as of March 31, 2015.
The following figure is an example of the concurrent presence of multiple drug-limit libraries in infusion-alert data (of a single hospital). The graph shows the number of infusion alerts (indicated by marker size and color) that was generated by a specific version of the drug-limit library (y-axis) on a given day from late 2013 to very early 2015 (x-axis). There seems to be more than five versions of the drug-limit library actively generating alerts in early October 2014.
Appendix D

Publications
Publications


Mondisa, J.-L., & McComb, S. A. Social Community: Understanding Students’ Connectedness to Promote Student Success.


Appendix E

Financials
# Financials

## Core and Extramural Funding

<table>
<thead>
<tr>
<th>Year</th>
<th>Regenstrief Foundation Core</th>
<th>Extramural</th>
</tr>
</thead>
<tbody>
<tr>
<td>2013-2014</td>
<td>$2,000,000</td>
<td>$2,960,259</td>
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<tr>
<td>2014-2015</td>
<td>$2,000,000</td>
<td>$541,619</td>
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</table>

**Subtotal**

$4,000,000  
$3,501,878
Appendix F

Metrics
# Metrics

## RCHE Metrics (2013–2018)

<table>
<thead>
<tr>
<th><strong>Foundation President and Purdue President meet twice annually</strong></th>
<th><strong>2013–2015 Progress</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>One to three seats on the Advisory Council</td>
<td>Academic Advisory Committee (Deans): May 28, 2014 Academic Advisory Committee: September 18 and 19, 2014 October 17, 2014</td>
</tr>
<tr>
<td>RCHE research with an objective of impact will include research, validation, and dissemination partners.</td>
<td>Partners for projects listed in Appendix C</td>
</tr>
<tr>
<td>RCHE research conducted to achieve pre-impact objectives will involve research partners as is appropriate for the specific research.</td>
<td>Partners for projects listed in Appendix C</td>
</tr>
<tr>
<td>Research funding from major national funding sources awarding competitive grant applications</td>
<td>Grants this period from: National Science Foundation U.S. Army (Medical Research Acquisition Activity)</td>
</tr>
<tr>
<td>Publish research findings and reports in peer-reviewed journals.</td>
<td>Publications listed in Appendix D</td>
</tr>
<tr>
<td>Conduct research in transdisciplinary teams</td>
<td>Ongoing</td>
</tr>
<tr>
<td>Research projects with impact objectives include active dissemination by one or more dissemination partners</td>
<td>Partners for projects listed in Appendix C</td>
</tr>
<tr>
<td>Partners will evaluate the center during the grant period</td>
<td></td>
</tr>
<tr>
<td>Evaluate research findings for impact on healthcare delivery</td>
<td></td>
</tr>
<tr>
<td>Help sustain HSEA</td>
<td>Serve as board member (Musselman) Maintain hub infrastructure for course and program dissemination</td>
</tr>
<tr>
<td>Host at least one HSEA conference</td>
<td>International webinar hosted February 26, 2015</td>
</tr>
<tr>
<td>At least three multi-university proposals</td>
<td>NSF ERC proposal submitted Fall 2013, with University of Wisconsin—Madison (not funded)</td>
</tr>
<tr>
<td>Gap analysis/benchmarking against at least two other centers</td>
<td></td>
</tr>
<tr>
<td>Evaluate effectiveness of research team in meeting objectives, dissemination success, and impact</td>
<td></td>
</tr>
<tr>
<td>Host two conferences annually</td>
<td>2013</td>
</tr>
<tr>
<td></td>
<td>2014</td>
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<td></td>
<td></td>
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<tr>
<td></td>
<td>2015</td>
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<tr>
<td></td>
<td></td>
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<tr>
<td>Host three nationally prominent speakers per year</td>
<td>Karl Gumpper</td>
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<tr>
<td>Assess healthcare-delivery hub as an improvement and knowledge community tool</td>
<td>*</td>
</tr>
<tr>
<td>Submit annual operating budget</td>
<td>Achieved</td>
</tr>
<tr>
<td>Document management of foundation funds &amp; submit monthly financial report</td>
<td>Achieved</td>
</tr>
<tr>
<td>Attain a core leverage ratio greater than or equal to 3.0</td>
<td>0.7 (April 2015)</td>
</tr>
</tbody>
</table>

Appendix G

Search Committee Members
Regenstrief Center for Healthcare Engineering
Director Search Committee

William M. Tierney, M.D.
President and CEO, Regenstrief Institute, Incorporated
Chancellor’s Professor and Sam Regenstrief Professor of Health Services Research
Associate Dean for Clinical Effectiveness Research
Indiana University School of Medicine

Elisa Bertino, PhD
Director of Cyber Center
Interim Director of CERIAS
Professor of Computer Science
Professor of Electrical and Computer Engineering (courtesy)
Purdue University

Hyunyi Cho, PhD
Associate Dean for Research and Graduate Education, College of Liberal Arts
Courtesy faculty, Department of Youth Development and Agricultural Education, College of Agriculture,
Professor, Brian Lamb School of Communication
Purdue University

Rebecca Doerge, PhD
Director, Departments of Agronomy and Statistics
Department Head, Statistics
Trent and Judith Anderson Distinguished Professor of Statistics
Professor, Statistical Bioinformatics Center
Purdue University

Marietta L. Harrison, PhD
Interim Director, Regenstrief Center for Healthcare Engineering in Discovery Park
Special Advisor Strategic Initiatives, Office of the Executive Vice President for Research and Partnerships
Associate Vice-President for Research
Director, Oncological Sciences Center in Discovery Park
Associate Director, Purdue Center for Cancer Research
Professor, Medicinal Chemistry and Molecular Pharmacology
Purdue University
David Hummels, PhD
Dean, Krannert School of Management
Professor, School of Economics
Purdue University

Martin Jischke, PhD
President Emeritus
Purdue University

David McKinnis, PhD
Director, Technical Assistance Program
Assistant Vice President for Engagement
Purdue University

Ken Musselman, PhD
Director, Strategic Collaboration, Regenstrief Center for Healthcare Engineering
Purdue University

Joseph Pekny, PhD
Interim Director of Burton D. Morgan Center for Entrepreneurship
Professor of Chemical Engineering
Purdue University

Cleveland Shields, PhD
Director, Center on Poverty and Health Inequities (Regenstrief Center for Healthcare Engineering)
Professor of Human Development and Family Studies, College of Health and Human Sciences
Purdue University

George Wodicka, PhD
Regenstrief Center for Healthcare Engineering Director Search Committee Chair
Professor and Head, Weldon School of Biomedical Engineering
Professor, Electrical and Computer Engineering
Purdue University

Yuehwern Yih, PhD
Director, Smart Systems and Operations Laboratory
Regenstrief Center for Healthcare Engineering Faculty Scholar
Professor of Industrial Engineering
Purdue University
Appendix H

Marietta Harrison Bio and CV
Marietta Harrison Brief Biography

Marietta L. Harrison was named Associate Vice President for Research in 2009 and Special Advisor – Strategic Initiatives Office of Research and Partnerships in 2014 at Purdue University. In this position she is charged with responsibility for various aspects of research administration, internal funding, internal research policies and aspects of research stewardship.

Harrison is a professor in the Department of Medicinal Chemistry and Molecular Pharmacology and serves as the Director of the Oncological Sciences Center and Interim Director of the Regenstrief Center for Healthcare Engineering in Discovery Park and the Associate Director for the Purdue University Center for Cancer Research. Her research interests lay in the area of immune cell activation and the role of immunity in cancer surveillance. The Harrison laboratory studied the mechanisms underlying the function of the pivotal tyrosine kinase Lck and the group has published over 70 articles in peer-reviewed journals.

Harrison served as a member of the NIH Experimental Immunology Study Section and as an ad hoc reviewer for the NIH Allergy and Immunology Study Section, the Transplantation, Tolerance and Tumor Immunology Study Section and various NIH Special Study Sections. She served two terms on the Editorial Board of the Journal of Biological Chemistry and as a standing member of the ASBMB Human Resource Committee. She is the recipient of the Lafayette Lions Purdue Cancer Research Award,

Walther Cancer Institute “Collaborator of the Year Award” and is designated a 2009 Women of Purdue honoree.

Harrison received a doctoral degree in biochemistry from the University of Wyoming in 1980 and holds a bachelor’s degree in chemistry from the University of New Hampshire.
Marietta Harrison CV

Curriculum Vitae

Marietta Lambert Harrison

Professor of Medicinal Chemistry
Department of Medicinal Chemistry and Molecular Pharmacology
College of Pharmacy
Purdue University
West Lafayette, IN 47907
Phone: 765-494-1442
Email: harrisom@purdue.edu

Interim Director, Regenstrief Center for Healthcare Engineering
Mann Hall, Discovery Park
Purdue University
Phone: 765-494-4231
Email: harrisom@purdue.edu

Director, Oncological Sciences Center
Hall for Discovery Research and Learning, Discovery Park, Purdue University

Associate Director, Purdue University Center for Cancer Research
Hansen Life Sciences Research Building, Purdue University

Special Advisor - Strategic Initiatives
Office of the Executive Vice President for Research and Partnerships, Purdue University

Training and Experience
1966-1970 University of New Hampshire, B.A., Chemistry
1970-1973 Research Technician, Department of Biophysics, Harvard University, Cambridge; Director: Bert L. Vallee, MD
1973-1975 Research Technician, Department of Nephrology, University of Vermont, Burlington; Director: Michael J. Dunn, MD
1975-1980 University of Wyoming, Laramie; Ph.D., Biochemistry; Advisor: Clarence L. Villemez, PhD
1980-1982  Postdoctoral Fellow, Division of Tumor Immunology, Fred Hutchinson Cancer Research Center, Seattle; Directors: Karl Erik Hellström, MD, PhD and Ingegerd Hellström, MD, PhD

1983-1985  Visiting Assistant Professor, Department of Medicinal Chemistry and Pharmacognosy, Purdue University, West Lafayette, IN

1986-1989  Assistant Research Scientist, Department of Medicinal Chemistry and Pharmacognosy, Purdue University

1989-1993  Assistant Professor, Department of Medicinal Chemistry and Molecular Pharmacology, Purdue University

1993-1999  Associate Professor, Department of Medicinal Chemistry and Molecular Pharmacology, Purdue University

1999-present  Professor, Department of Medicinal Chemistry and Molecular Pharmacology, Purdue University

1996-1998  Assistant Director, Purdue University Center for Cancer Research

1998-present  Associate Director, Purdue University Center for Cancer Research

2005-2007  Interim Director, Oncological Sciences Center, Discovery Park, Purdue University

2007-present  Director, Oncological Sciences Center, Discovery Park, Purdue University

2009-2014  Associate Vice President for Research, Purdue University

2011-present  Interim Deputy Director Bindley Bioscience Center, Discovery Park

2014-present  Special Advisor-Strategic Initiatives, Office of the Executive Vice President for Research and Partnerships, Purdue

2015  Interim Director, Regenstrief Center for Healthcare Engineering

**Professional Activities**

1994  Member, NIH Special Study Section 2(ZRG7-SSS-2MGN-BLS)

1995-2000  Editorial Board, *Journal of Biological Chemistry*

2003-2008  Editorial Board, *Journal of Biological Chemistry*

1996  NIH Allergy and Immunology Study Section (Ad Hoc)

1996-1999  American Society for Biochemistry and Molecular Biology (ASBMB) Human Resources Committee

1997-2001  Member, NIH Experimental Immunology Study Section
2002  Member, NIH Special Study Section ZRG1 EI (02)
2003  Member, NIH Special Study Section ZRG1 SSSF-F (03)
2003  NIH Experimental Immunology (EI) Study Section (Ad Hoc)
2005  Member, NIH Special Study Section ZRG1 IMM-A
2006  NIH Transplantation, Tolerance and Tumor Immunology Study Section (Ad Hoc)
2008  NIH Cellular and Molecular Immunology-A Study Section (Ad Hoc)
2009  NIH Transplantation, Tolerance and Tumor Immunology Study Section (Ad Hoc)

Professional Societies
American Society for Biochemistry and Molecular Biology
American Association for Cancer Research
American Society for Microbiology

Honors and Fellowships
Gamma Sigma Delta, Honorary Society, University of Wyoming, 1979
Recipient, National Institutes of Health, National Research Service Award, 1981-1983
Lions Club Purdue Cancer Research Award, 1988
SNPhA (Student National Pharmaceutical Association, Minority Students) Appreciation Plaque (1998)
Purdue Seed for Success Award, 2003
Walther Cancer Institute Collaborator of the Year Award, 2007
Purdue Seed for Success Award, 2007
Purdue Seed for Success Award, 2008
SNPhA (Student National Pharmaceutical Association, Minority Students) Appreciation Plaque (2009) Woman of Purdue honoree by the Barbara Cook Chapter of Mortar Board, 2009

Community Service
2015  Clinical Research Board, IU Health Arnett
University Service

Current:
Interim Director, Regenstrief Center for Healthcare Engineering
Director, Oncological Sciences Center, Discovery Park
Associate Director, NCI-designated Purdue University Center for Cancer Research
Special Advisor – Strategic Initiatives, Office of the Executive Vice President for Research and Partnerships
Executive Vice President for Research and Partnerships liaison to the IN School of Medicine
Chair, Research Faculty Working Group
Purdue Representative, Federal Demonstration Partnership
Purdue representative to the Indiana Biosciences Research Institute
Search Committee, Department Head, Medicinal Chemistry and Molecular Pharmacology
Search Committee, Director of the Regenstrief Center for Healthcare Engineering
Search Committee, Executive Director Indiana Center for Musculoskeletal Health, Indiana University School of Medicine
Search Committee, Pharmacy Practice Assistant Professor(s)
Internal Steering Committee, Women’s Global Health Institute, Purdue University

Past Five Years:
Search Committee, Associate Vice President for Research, Regulatory Affairs
Member, Indiana CTSI Core Oversight Committee
Member, Internal Advisory Committee, Susan G. Komen for the Cure® Tissue Bank
at the IU Simon Cancer Center
Search Committee (Chair), Associate Dean for Research and Graduate Programs, College of Health and Human Sciences
Search Committee, Associate Dean of Research and Graduate Education, College of Science (2011)
Search Committee, Director, Birck Nanotechnology Center in Discovery Park (2011)
Chair, PUBAMS Spring 2010 International Membranes Symposium

Selected Previous Service:
Co-chair, Purdue University Strategic Planning Committee, Large Scale Research and Infrastructure (appointed by President France Córdova) (2008)

Search Committee, Vice President for Research, Purdue University (appointed by President France Córdova) (2008)

Steering Committee, Cancer-Oncology Summit (IN Health Industry Forum) (2008)

Search Committee, Director Purdue Cancer Center (2006)

Sigma Xi (Purdue Chapter), Executive Committee (2002-2006)

Search Committee, Director Purdue Cancer Center (2005)

Minority Advocacy Committee, School of Pharmacy (1993-2001; 2003-2005)

Departmental (MCMP) Executive Committee (2001-2005)

PULSe (Purdue University Life Sciences Interdisciplinary Graduate program) Planning Subcommittee (2003)

MCMP Cumulative Examination Committee (2002-2005)

MCMP Curriculum Committee (1999-2004)

Discovery Park Task Force Strategic Planning Committee (2002)

Department of Medicinal Chemistry and Molecular Pharmacology Strategic Planning Committee (2002)

Faculty Advisor, SNPhA (Student National Pharmaceutical Association, Minority Students) (1993-1996; 2002-2005)

Faculty Advisor and Mentor, Purdue Initiative for Minority Student Development (IMSD) (1996-2000)

Examining Committee BMB (renamed PULSe, Interdisciplinary Life Sciences Graduate Training Program) (1990-1996)

Graduate Opportunity Fellowship Committee (formerly Women, Black and Other Ethnic Minorities Committee) 1991-1996

Purdue Community Relations

Community Cancer Network Board of Directors; Lafayette, IN (2008-2013)

Cancer Research Clinical Partnership Program; Co-founder with Wael Harb, MD; Lafayette, IN (2006-present)

Cancer Culture and Community Program; Founder; Greater Lafayette Community, IN (2006-present)
Publications


dissociation from the B-cell antigen receptor is mediated by phosphorylation of tyrosine-
130, J. Biol. Chem. 272, 10377-10381.

acetogenin Bullatacin is cytotoxic against multidrug resistant human mammary
adenocarcinoma cells, Canc. Lett. 115, 73-79.

and assay of protein kinases after electrophoresis in SDS-polyacrylamide gels," in Protein
Phosphorylation (Sefton, B.M. and Hunter, T., eds.) Academic Press, pp. 169-175.

44. Keshvara, L.M., Isaacson, C., Yankee, T.M., Sarac, R., Harrison, M.L. and Geahlen, R.L.
(1998) Syk- and Lyn-dependent phosphorylation of Syk on multiple tyrosines following B-
cell activation includes a site that negatively regulates signaling, J. Immunol. 161, 5276-
5283.

45. Fernandez, J.A., Keshvara, L.M., Peters, J.D., Furlong, M.T. Harrison, M.L. and Geahlen,
Syk and the tyrosine kinase substrates Cbl and Vav with tubulin in B-cells, J. Biol. Chem.  
274, 1401-1406.

Engagement of β1 integrins on promonocytic cells promotes phosphorylation of Syk and
formation of a protein complex containing Lyn and β1 integrin, Eur. J. Immunol. 29, 1426-
1434.

Inhibition of signaling through the B cell antigen receptor by the proto-oncogene product, c-
Cbl, requires Syk tyrosine 317 and the c-Cbl phosphotyrosine-binding domain, J. Immunol.  
163, 5827-5835.

recognition by the Lyn protein-tyrosine kinase: NMR structure of the immunoreceptor
tyrosine-based activation motif signaling region of the B-cell antigen receptor, J. Biol. 
Chem. 275, 16174-16182.

Visualization of Syk-antigen receptor interactions using green fluorescent protein:
differential roles for Syk and Lyn in the regulation of receptor capping and internalization, J. 
Immunol. 166, 1507-1516.

SH3 domain negatively regulates localization to lipid rafts through an interaction with c-Cbl,
J. Biol. Chem. 227, 5683-5691.

The oxygen-substituted palmitic acid analog, 13-oxypalmitic acid, inhibits Lck localization to
lipid rafts and T cell signaling, Biochim. Biophys. Acta 1589, 140-150.


**Manuscripts in Preparation**


4. Vázquez, M.L., Geahlen, R.L., and Harrison, M.L. “Nck is a Unique Binding Partner of Lck and the Nck/Lck Interaction is regulated by the phosphorylation of serine 59 in Lck”
**Major Research Funding**

**CURRENT**

**Walther Cancer Foundation** 06/1/2010-5/31/2016

**Walther Oncology Physical Sciences & Engineering Research Embedding Program**

The goal of this program is to create research embedding teams consisting of newly minted engineering or physical sciences postdoctoral fellow, a medical fellow, IUSCC oncology faculty mentor and a Purdue/Physics/Chemistry/Engineering faculty mentor.

Role: PI 0.0 cal. mon.

**Walther Cancer Foundation** 06/01/2010-05/31/2016

**Cancer Care Engineering Genomics Project**

This award supports the next-gen sequence analysis of colon cancer tissue samples and the data analysis and modeling of the data for biomarkers of risk of disease and progression.

Role: PI 0.0 cal. mon.

**NIH 5P30 CA23168 National Cancer Institute** 07/01/10-06/30/15

**Cancer Center Support Grant**

This is an institutional grant that supports the Purdue Center for Cancer Research programs and resources.

Role: Co-PI, 0.6 cal. mon. (PI, Ratliff)

**Major Research Funding**

**PREVIOUS**

**NSF:DMS/NIH:NIGMS DMS: 0900277 (Joint Program)** 09/01/2009-8/31/2013

**Quantitative Design of Experiments to Predictably Alter Intracellular Signaling Dynamics**

The project focuses on generating predictive mathematical models for describing signaling pathways in cells.

Role: Co-PI, 1.2 cal. mon. (PI, Rundell)

**NIH CTSA SUPPLEMENT 3UL1RR025761-4S2** 9/01/2011-4/30/2012

**Infrastructure to Enable Community Based Clinical Trials for Biomarker Discovery**

This project focuses on developing an interfacing infrastructure to capture and deposit e-medical records at the community-based IUHealth Arnett hospital into the Purdue University cceHUB database.

Role: Purdue PI; 0.6 cal. mon (CTSI PI Anantha Shekhar, Indiana University)

**DOD USAMRMC (CDMRP) 09107003** 2/07/2010-1/31/2012

**Cancer Care Engineering (CCE)**

This project enlarges the patient base for CCE, increases the biological assays to eight, and expands CCE to include a cost benefit analysis of colon cancer prevention screenings and delivery of colon cancer care.

Role: Co-Purdue PI with Pekny; 0.3 cal. mon. (PI Loehrer, Indiana University)
Cancer Care Engineering (CCE)
This project focuses on identifying “molecular signatures” of colon cancer in the blood and tissues of colon cancer patients by performing six simultaneous assays for detecting colon cancer biomarkers and creating a single cyber infrastructure to store, analyze, integrate, and model annotated clinical data.
Role: Co-Purdue PI with Pekny; (Loehrer PI)

Tyrosine Protein Kinase and Lymphocyte Activation
These studies focus on the role of the tyrosine kinase Syk in mediating signaling through the B cell receptor.

Developing a Hierarchical System Based Approach to Improving Cancer Care: Establishing an Indiana Prototype for Next-Generation Colorectal Cancer Care
Role: Co-PI (Pekny PI)

Cancer Care Engineering Infrastructure
This award supports the project management infrastructure for the Cancer Care Engineering project.
Role: PI

Chemical Probes of Protein Prenylation
These studies focus on the development of tools for studying protein farnesylation
Role: Co-PI (Gibbs PI)

Characterization of Lck and Associated Proteins
The studies address the role of the intramembrane localization and serine phosphorylation in the function of the protein tyrosine kinase Lck.

Tyrosine Protein Kinase and Lymphocyte Activation
Role: Co-PI; 1.2 months (calendar year); (Geahlen PI)

Chemical Probes of Protein Prenylation
Role: Co-PI; 0.6 months (calendar year); (Gibbs PI)

Characterization of Lck and Associated Proteins
(P.I., M. L. Harrison, Co-P.I., R.L. Geahlen)
Trainees

<table>
<thead>
<tr>
<th>Previous graduate students</th>
<th>Degree</th>
<th>Year</th>
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<tbody>
<tr>
<td>Carolyn Ford*</td>
<td>Ph.D.</td>
<td>1995</td>
</tr>
<tr>
<td>Nuzhat Pathan</td>
<td>Ph.D.</td>
<td>1996</td>
</tr>
<tr>
<td>Brian Skaggs</td>
<td>M.S.</td>
<td>1996</td>
</tr>
<tr>
<td>Robyn Midwinter</td>
<td>M.S.</td>
<td>1997</td>
</tr>
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José Fernandez* Ph.D. 1999
Kamala Kesavan Ph.D. 1999
Carla Edge** Ph.D. 2000
Zhongwen (Cindy) Yu M.S. 2001
Ibrahim Hawash Ph.D. 2002
Manqing Li Ph.D. 2004
Amy Krans M.S. 2007
Meredith Baker Ph.D. 2007
Mariá Luz Vázquez Ph.D. 2007
Misty Handley*** Ph.D. 2007
Maria Mogafegh M.S. 2009
Su Sien Ong Ph.D. 2010
Judith Mikolajczak Ph.D. 2012

* Awarded NIH Predoctoral Minority Fellowships
** ASBMB travel fellowship, CIC fellowship
*** Jenkins Knevel Outstanding Graduate Research Award, School of Pharmacy 2005

Currently I serve on 3 Graduate Advisory Committees and have served on over 60 in my tenure at Purdue

Postdoctoral Fellows Current Position
Pothur R. Srinivas Program Director, Division of Cardiovascular Diseases
National Heart, Lung and Blood Institute, NIH
Anissa Buckner Assistant Professor, Department of Ophthalmology,
University of Arkansas

Teaching experience
I have taught at Purdue University since 1987 in various chemistry, biochemistry, immunology and cancer courses. Below is list of the courses in which I have participated.

BCHM 322*, “Analytical Biochemistry” 2 credits (1987)
MDCH 310, “Quantitative Medicinal & Chemical Analysis” 3 credits (1987-1997)
MDCH 401, “The Nature of Cancer” 1 credit (1987-present)
MDCH 422*, “Immunology” 3 credits (1989-2007)
BIOL 221, “Introduction to Microbiology” 4 credits (1990)
VPB 620, “Advanced Immunology” 2 credits (1996-2005)
LCME 504, “Molecular Biology of the Cell” (IU Medical School-Lafayette) 3 credits (2007-2008)

*Course Coordinator

Public Presentations
Past Seven Years
“Discovery Park 2.0 – Creating Convergence”, September 2014
“Drug Discovery at Purdue”, Women for Purdue, June 2014
“Developing Better Medicine”, Summer Undergraduate Research Fellowship (SURF), College of Engineering, Purdue, June 2014
“Women’s Innovations in Science and Engineering”, March 2014
“Indiana CTSI – Engagement with IU Health Arnett”, CTSI Annual Retreat, April 2014
“The Joy of Discovery”, Undergraduate Research Forum, April 2014
“Purdue UMETRICS”, Federal Demonstration Partnership, Washington DC, January 2014
“Entering the Era of Precision Medicine”, WGH1 High Tea, September 2013
“Cancer Research at Purdue”, First Methodist Church, April 2013
“Developing Better Medicine”, Summer Undergraduate Research Fellowship (SURF), College of Engineering, Purdue, June 2013
“Personalized Medicine… It’s all about YOU”, Summer Undergraduate Research Fellowship (SURF), College of engineering, Purdue, June 13, 2012
“Personalized Medicine and Cancer Treatment”, 2010 Midwest Oncology Nursing Symposium, STEW, October 21, 2010

“Personalized Medicine… It’s all about YOU”, Science on Tap, Lafayette, IN, May 20, 2010

“Cancer Research at Purdue,” Jackson County Purdue Alumni Club Annual Dinner, Logansport, IN, April 16, 2010

“Cancer Research at Purdue,” Cass County Purdue Alumni Club Annual Dinner, Logansport, IN, June 9, 2009

“Work/Family Life Balance and Mentoring/Career Advancement,” Pharmacy Women for Purdue Conference Panel, Purdue University, April 24, 2009

“Conquering Cancer: Will Science Win?,” Keynote Speaker, Sigma Xi Annual Dinner, Purdue University, April 22, 2009

“Purdue Cancer Center: Moving Toward a Cure,” Back to Class Purdue University, Naples, FL, February 14, 2009

“Cancer Research at Purdue,” Department of Health and Kinesiology, Purdue University, November 5, 2008

“Purdue Cancer Center: Moving Toward a Cure,” Back to Class, Purdue University, October 24, 2008

“Signaling from Golgi Membranes in T cells,” Frontiers in Biological Membranes Symposium, Purdue University Center for Basic and Applied Membrane Sciences, October 17, 2008

“Cancer, New Thoughts on an Old Disease,” Keynote Speaker, Indiana Association of Family and Consumer Sciences, Centennial Meeting, Indianapolis, IN, September 25, 2008

“New Approaches to Cancer Treatment, Early Detection, Individualized Care, Molecular Targeted Therapy, Genomics and Proteomics,” Hoosier Oncology Group, Inc. Educational Symposium, Purdue University, August 19, 2008

“Research@Purdue: Discovery Park and Collaborations,” New Faculty Orientation, Purdue University, August 20, 2008
