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# Program Committee Report December 2015

Regenstrief Center for Healthcare Engineering

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# **Project Summaries**

## About the Project Summaries

The project summaries provide general information about RCHE’s current research. 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. 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

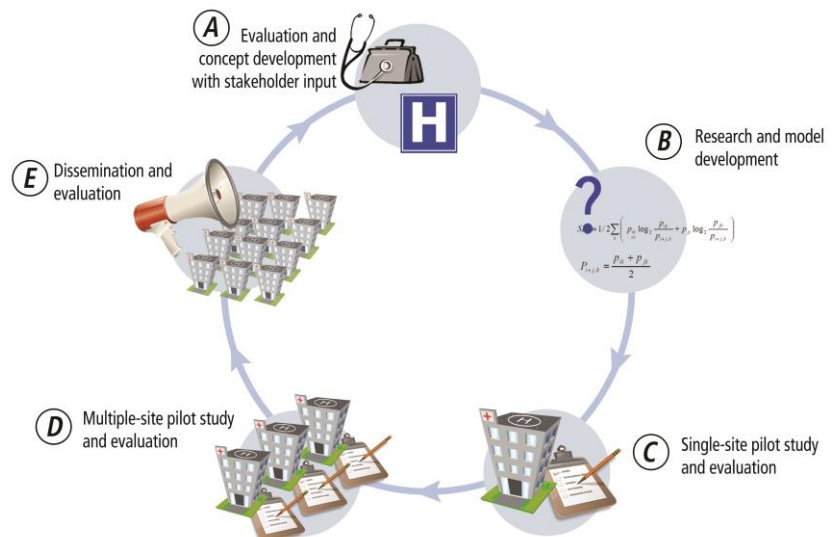
### Project Matrix

Project Title 1	Page 2	Research-to- Impact Phase 3				
		A	B	C	D	E
<b>Care Efficiency and Improvement</b>						
Supporting Communities of Practice to Improve Healthcare Delivery - REMEDI	5					
Development of the REMEDI Informatics System - REMEDI	7					
Smart Pump Alert Threshold Decision Support - REMEDI	9					
Valuing the Impact of Adopting the REMEDI Database System - REMEDI	12					

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

Project Title	Page	Research-to-Impact Phase				
		A	B	C	D	E
<b>Care Efficiency and Improvement</b>						
Supporting Communities of Practice to Improve Healthcare Delivery - REMEDI	5					
Development of the REMEDI Informatics System - REMEDI	7					
Smart Pump Alert Threshold Decision Support - REMEDI	9					
Valuing the Impact of Adopting the REMEDI Database System - REMEDI	12					
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Project Title	Page	Research-to-Impact Phase				
		A	B	C	D	E
<b>Advanced Engineered Diagnostics and Devices</b>						
See-What-I-Do: Increasing Mentor and Trainee Sense of Co-Presence in Trauma Surgeries with the STAR Platform	37					
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Wellness Coaching Impact on Employee Health Outcomes	53					
Interventions to Improve Type 2 Diabetes (T2DM) Adherence & Outcome in Rural Indiana: A Randomized Controlled Trial	55					
All-Cause Unplanned and Preventable Readmissions Reduction	57					
<b>Total</b>		<b>2</b>	<b>10</b>	<b>2</b>	<b>4</b>	<b>3</b>

## Care Efficiency and Improvement

# Supporting Communities of Practice to Improve Healthcare Delivery - REMEDI

### *Research Team*

#### Faculty

Marietta Harrison, Regenstrief Center for Healthcare Engineering

#### Staff

PI: Rich Zink, Regenstrief Center for Healthcare Engineering  
Ken Musselman, Regenstrief Center for Healthcare Engineering

#### Healthcare Partners

##### Infusion Pump Informatics (IPI) providers:

- Aurora Health
- 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
- Intermountain Healthcare
- Madison Middleton VAMC
- Metro Health Hospital
- Parkview Health System
- St. Mary's Hospital
- St. Vincent Health System
- University of California Davis Medical Center
- University of Iowa Health Care
- University of Nebraska Hospital
- University of Wisconsin Hospital
- Witham Hospital

##### Infusion Pump Informatics (IPI) vendors:

- Carefusion (Becton Dickinson)
- Hospira
- Baxter
- B. Braun (Pending)
- Smiths Medical (Pending)

##### 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 and 2015 by the ECRI institute.

**Research Objectives** The evidence-based communities of practice approach provides sharing of information among 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, etc.

**Methodology** The scientific collaboration platform, [www.CatalyzeCare.org](http://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** This project, leveraging the success of the evidence-based community of practice model demonstrated by the IPI community, is expanding to support new communities of vendors and clinicians under the REMEDi umbrella. Key activities for this period include the engagement of physiological monitor vendors, progress in the development of a drug library analysis package, and the kickoff of a pilot project with IUH Arnett to link medical device data to the patient record.

## Development of the REMEDi Informatics System - REMEDi

### *Research Team*

**Staff**

PI: Michael Zentner, ITaP/Research Computing

**Healthcare Partner**

Aurora Health  
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  
Intermountain Healthcare  
Madison Middleton VAMC  
Mercy Cedar Rapids  
Metro Health Hospital  
Parkview Health System  
St. Mary's Hospital  
St. Vincent Health System  
University of California Davis Medical Center  
University of Iowa Health Care  
University of Nebraska Hospital  
University of Wisconsin Hospital  
Witham Health Services

### *Research Direction*

**Competencies**

Data visualization  
Databases

**Research-to-Impact Phase**

Phase E (Dissemination and evaluation)

**Research Timeline**

July 2015 – June 2016



## **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. Maintenance of the IPI infrastructure: database, middleware, data processors, and graphical interface
2. Support of users
3. Development of new IPI platform that will support over 1,000 hospitals
4. Performance testing to understand impact of thousands of hospitals on IPI performance
5. Report analysis to identify which of the 100+ reports are used by clinicians
6. Integration of B. Braun and Smiths Medical pumps

### **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 highlights this period include a change in the development team, now led by Mike Zentner, and the onboarding of Mercy Cedar Rapids and the University of California Davis Medical Center.

## Smart Pump Alert Threshold Decision Support - REMEDI

### Project Team

#### Faculty

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

#### Students

Jeong Joon Boo (graduate, summer/fall, 2015), Industrial Engineering  
Fem Ozcan (undergraduate, spring 2015), Industrial Engineering  
Ryan Widjaja (undergraduate, fall 2014), Industrial Engineering  
Ziya Zhao (undergraduate, spring/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 that alerts that sound frequently typically have the most number of false alarms, it could also be that the alerts need to sound in order 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), of altering the guard rail. This tool will be implemented within the Infusion Pump Informatics 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 been collaborating with Dr. Yuval Bitan of HumanEra on identifying the mental models of nurses when interacting with the infusion pump system. This work should help understand how we might assist nurses in responding properly to alerts.

### 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. The algorithm works by shifting the soft limits for the 27 hospitals available through the IPI database. An analysis of the impact of a simple rule for setting thresholds was conducted and indicated that a simple threshold could possibly reduce the total number of alarms while also reducing missed detections for approximately 60% of the 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.

The analysis that is currently in progress will determine whether these benefits can be achieved in a practical application scenario, and what that practical operational concept is, while not increasing the number of missed detections. We are also working on implementing the prototype

within the infusion pump informatics web tool in order to conduct usability testing.

I continue to have regular teleconferences with Dr. Bitan, and we have developed a survey and associated methodology that we will use in support of the mental model research. The survey is being developed in collaboration with nurses from the infusion pump informatics group and with nurses at Purdue. We expect the survey to be disseminated by the end of the year.

Lastly, a larger NSF/NIH proposal was developed and submitted as an offshoot of this work, with Dr. Elisa Bertino (CS) as PI. The proposal received the highest ratings from the panel, but was not funded due to “portfolio concerns.” The panel recommended having the NIH fund the work, and Dr. Bertino is pursuing this option.

# Valuing the Impact of the REMEDi Database System – REMEDi

## Research Team

Faculty/Staff Poching DeLaurentis, Regenstrief Center for Healthcare Engineering  
Mark Lehto, Industrial Engineering

Student Kerina Wan-Ting Su, Industrial Engineering

Healthcare Partners TBD

## Research Direction

Competencies Data mining and analytics  
Pattern and clustering analysis  
Health economics/pharmacoeconomics  
Human-machine interactions

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

Research Timeline Phase I: Summer 2015 – Spring 2016. Phase II: Summer 2016 – Spring 2017

## 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. We work to identify quantifiers or performance measures either from the IPI data or other feedback from our IPI members to evaluate the impact of adopting of the IPI System.

Research Objectives The quantification of value created by adopting smart pumps plus the IPI System can justify RCHE's investments on the IPI System operations and maintenance and its contribution to patient safety. This analysis framework will be applied to all medical devices contributing data to the REMEDi system.

Methodology We will identify any relevant adverse drug events (ADEs) and patient safety studies in the literature of selected infusion drugs with special focus on associated costs and clinical outcome consequences and use the information to quantitatively estimate the cost averted using drug alert data in the IPI System. Specifically we will start by focusing on high alerting drugs and comparing their alert counts and patterns between facilities. We will seek input from some IPI users and research

collaborators with domain expertise and knowledge to help guide us in this project.

#### Potential Impact

A framework of quantifying savings in terms of monetary and clinical outcome measures of potential infusion errors will allow researchers to demonstrate the value of utilizing smart infusion pumps in conjunction with the IPI System. This framework will be used as an integral part of cost-benefit analyses of the adoption of similar medical device technologies. We also envision an extension on studying the effectiveness of the drug limit alert system, including the humans and machines, in the context of warning system design, optimal team decision making and conceptual models of human information process and behavior.

#### Project Update

We began our project by exploring the IPI data. Based on the starting dates of IPI membership of a few selected members, we defined one year before and after their adopting of the IPI System to be the comparing periods. Our overarching hypothesis is that once a hospital group starts using the IPI System, the available drug alert analytics and knowledge sharing of the community can help the organization understand, evaluate and improve its infusion process, drug limit settings, nursing education, etc., and therefore, its drug alerts and alert patterns will reflect such improvement when compared to those from before using the IPI System.

We first analyzed some basic measures of drug alerts in these facilities including drug alert frequency of a few high risk medications, their alert override frequency and override ratio for the two periods, and compared the change over time. Further we identified and analyzed the level of drug overdosing range and quantified the averted and potential overdosing harm for each facility using a IV Medication Harm Index scoring method (Williams et al. 2006). Although this analysis is largely work-in-process, our initial results do show some clear differences in infusion drug alert patterns when comparing them from before and after IPI adoption.

## Drug Limit Library Database and Research - REMEDI

### Research Team

Faculty/Staff	PI: Poching DeLaurentis, Regenstrief Center for Healthcare Engineering Rich Zink, Regenstrief Center for Healthcare Engineering Yuehwern Yih, Industrial Engineering
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 such database to understand setting of drug limits and other relevant questions.

2. Construction of a searchable drug limit library/database and interactive display
  - a. Identify and define what to 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/combined and methods
    - How to resolve format differences of DLLs from various pump vendors?

- c. Design the dynamic drug limit library/database and 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
3. Analysis of the drug limits
- a. Compare and contrast selected drug limits in the alert data vs non-alert data
  - b. Study how drug limits evolve/converge over time
  - c. Investigate the factors involved in setting drug limits  
Some specific questions may be:
    1. Which drugs are reviewed the most?
    2. Is there a convergence in limits for the community?
    3. Do those that access the database make more changes?
    4. What do the users view?
    5. Do those that access the database more decrease the number of alerts/device? This would be a cross-database analysis (Requires data from the IPI database)
    6. How are the alert patterns different of different drug limits set for a particular drug?
      - Comparison of 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, etc.

#### 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 kick-off meeting took





## Drug Limit Library Update Process - REMEDI

### Research Team

#### Faculty/Staff

Poching DeLaurentis, Rich Zink, Regenstrief Center for Healthcare Engineering

Collaborator: Yuval Bitan, Department of Industrial Engineering and Management, Ben-Gurion University of the Negev, Beer-Sheva, Israel

#### Student

Ana Isabel De la Hoz Armenta, Industrial Engineering visiting undergraduate research student from the Universidad Nacional in Medellín, Colombia

#### Healthcare Partners

Eskenazi Health, Community Health Network

### Research Direction

#### Research Focus Area

Care Coordination

#### Competencies

Human Factors  
Data mining  
Pattern and clustering analysis  
Data visualization

#### Research-to-Impact

Phase B (research and model development)

#### Research Timeline

3/2015–12/2015

### 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 on drug infusions. From time to time, there may be changes or updates 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 if 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 practice and improve the reliability of it. 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/dataset 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

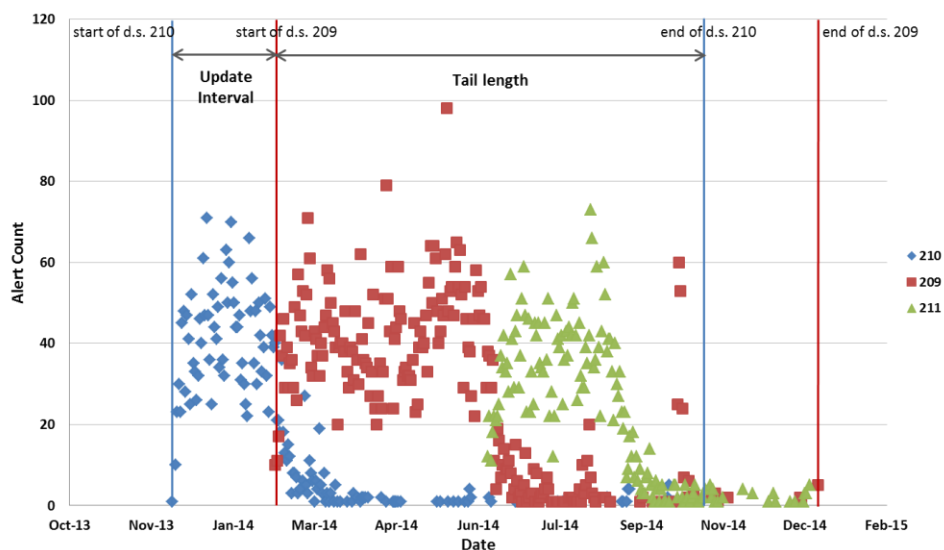
The results of this project will illustrate some issues relevant to adopting smart infusion pumps with wireless capability. Automatic updating of a pump is an assumed reliable feature, but our data show human intervention or workflow redesign is needed to ensure that all pumps are up-to-date in a hospital. This work will also shed light on the broader question regarding the design and implementation of interoperability of future medical devices in the interconnected network clinical environment.

### Project Update

We have taken two approaches to illustrate this DLL update delay problem. One is using drug alert data from our IPI system. The other is the device management data (i.e., from a pump tracking software) available to Carefusion pump users.

Approach 1: We have analyzed drug limit library update history based on drug alert data in our IPI database. The focus is on utilizing drug alert data to show that pump update process can be very lengthy and unreliable. In the ideal situation in which the pumps communicate well with the network server, DLL updates should distribute quickly over the wireless network. Once a new version of the DLL is activated, no pump should be using an older version of the DLL within a short period of time. In the figure below, the position of each marker indicates the date (x-axis) and the DLL version (y-axis) of the alerts while the marker size represents the number of alerts of such combination. The long “tail”, or the over-run duration of a DLL, represented by each horizontal trace of markers shows the ineffective process of pump updates.

A long delay in updating every single pump in the system may cause unsafe medication infusions in some scenarios and staff confusion.



Alerts generated by different DLL versions over time

This delay in wireless update of the DLL on smart infusion pumps is not a unique phenomenon found in one hospital but across hospital groups within our IPI community. We further characterized this update delay by measures such as the “update interval”, “tail length”, “average count of DLL versions per day”, etc. An update interval is defined as the time lapse between the activation dates of two consecutive issued DLLs. A “tail length” is the time from the date that one DLL is replaced by a newer version (i.e., the activation of a newer version of DLL) to the last day an alert is recorded using this replaced DLL version. The average count of DLL versions per day simply is the average number of DLL versions recorded in the alert data on any given day. Figure 1 also illustrates some of these measures.

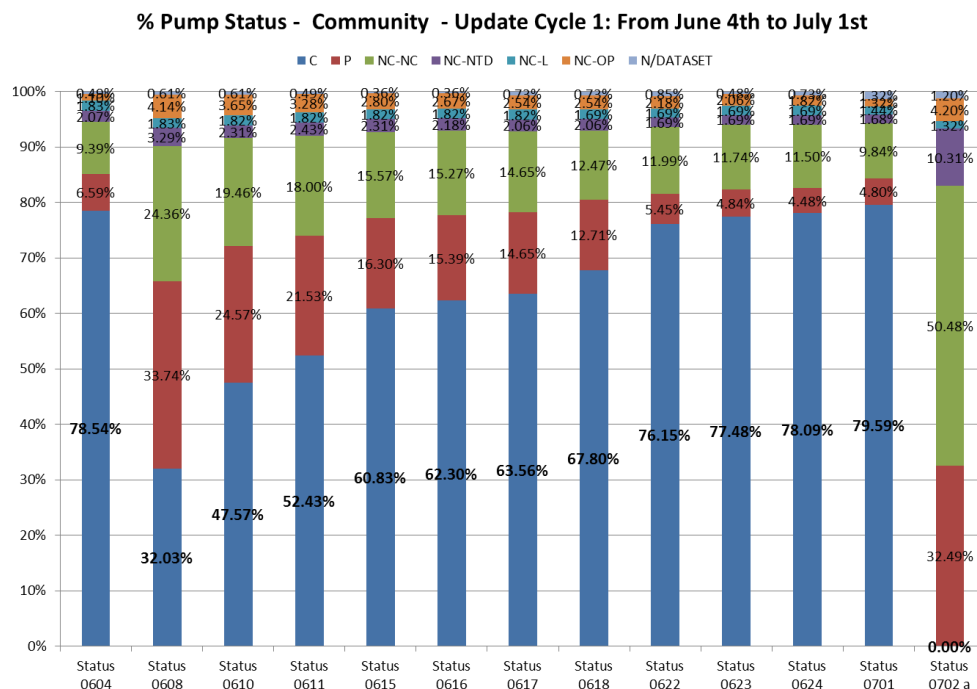
The preliminary results of this analysis using alert data from eight hospital groups show that smaller facilities tend to have shorter “tail length”, which means that the prolonged delay of DLL updates are less pronounced in hospitals with fewer number of pumps. The analysis remains as work-in-progress, and we are working to submit a manuscript reporting our findings very soon.

Approach II:

We have been working with Eskenazi Health and Community Health Network (CHN) and receiving their pump status reports exported from Carefusion’s pump management software. Since at any given time such report is a snapshot of the status of all pumps in the system, we needed

to collect such file as frequent as we could, such as daily, to be able to keep reasonable close track of how pumps change their status.

The pump status report lists all pumps that have been added to the hospital IT server system to date. It shows pump relevant information including the location/facility, model number, serial number, activated dataset (i.e., DLL version), dataset on the pump at the time this report was generated, pending DLL version, last communication timestamp and profile (which typically indicates its last known general location). We use this series of pump status information to classify each day whether a pump is *Current*, *Pending*, or *Not Current*, and we track the progression of the pumps becoming *Current* throughout an update cycle which is from the activation date of one DLL version to the activation date of the next DLL version. The following figure shows a typical progression of the overall pump update progress throughout an update cycle. We have observed that typically 60% to 80% of all pumps in these facilities would become *Current* by the end of an update cycle which may be about 30 days or more depending on each hospital's practice. A more detailed look at the exact time each pump was observed *Current* reveals that, for one specific hospital, only 58% of the total pumps were up-to-date at the end of three update cycles in 2015.



Pump status progression for one update cycle

As we continue the collection of pump update reports from our pharmacists collaborators, we are looking into all possible factors that are affecting the pump update process, whether it is hardware, software or operational workflows. Our next step includes building a computer simulation to model the dynamic of these factors and the pump and computer server network overall system.

# Nursing Attitudes and Perceived Causes of IV Pump Workarounds

## Research Team

Faculty	PI: Ben Dunford, Management
Students	Matthew Perrigino, Management
Healthcare Partners	University of Iowa Health Care, Eskenazi Health, 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 being 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

Since our last report, the following papers stemming from this project have been published, accepted for presentation at conferences, or are currently under review.

#### **Published papers not previously reported**

Perrigino, M., Dunford, B. B., Gaston, C., & Berndt, D. Taking another view: How nurses perceive infusion pumps as demanding for both themselves and their patients. In press at *Journal of Infusion Nursing*.

Perrigino, M., & Dunford, B. B. The Unique Effects of General and Specific Support in Healthcare Technology: An Empirical Examination of the Principle of Compatibility. In press at *Healthcare Management Review*.

#### **Papers accepted for presentation at academic conferences**

Perrigino, M. B., Dunford, B. B., Vermace, B. J., & Tucker, S. Generational differences and Healthcare Technology Satisfaction. Nursing Odyssey Conference, Sigma Theta Tau International Nursing Honor Society. Ontario, CA. (2015, October).

Dunford, B. B., & Perrigino, M. The Organization Made Us Do it: Demanding Formalization and Workaround Attributions. Paper presented at the Academy of Management Annual Conference. Vancouver, British Columbia, CA. (2015, August).

Perrigino, M., & Dunford, B. B. Deontic Technology Perceptions: A Complimentary View to Perspectives on Technology Acceptance Paper presented at the Academy of Management Annual Conference. Vancouver, British Columbia, CA. (2015, August).

Dunford, B. B., & Perrigino, M. The social construction of workarounds in organizational hierarchies. Paper presented at the Labor and Employee Relations Association. Pittsburgh, PA (2015, May).

Dunford, B. B. Linking work practices and organizational outcomes in the healthcare industry. Symposium Co-Organizer. Labor and Employee Relations Association. Pittsburgh, PA (2015, May).



Perrigino, M. B., Dunford, B. B., Berndt, D., & Gaston, C. L. Taking another view: How nurses perceive infusion technology are demanding for both themselves and their patients. Paper presented at the Infusion Nurses Society Annual Conference. Louisville, KY. (2015, May).

#### **Papers currently under review**

Dunford, B. B., & Perrigino, M. B. The Organization Made Us Do it: Demanding Formalization and Workaround Attributions. Under review at *Administrative Science Quarterly*.

Dunford, B. B., & Perrigino, M. The social construction of workarounds in organizational hierarchies. Paper under review at *Advances in Industrial Labor Relations*.

Perrigino, M., & Dunford, B. B., Vermace, B. J., Tucker, S. J., & Remphur, K. The Role of Social Context on the Relationship between Generational Differences and Healthcare Technology Satisfaction. Revise and resubmit at *Nursing Quarterly*.

We have exhausted all analyses of the data we collected from Iowa, Eskenazi and Wisconsin. We will continue to update the foundation on the progress of papers currently under review. With multiple papers either published or in the review process, no new papers will be started from this data set.

Thus, we are closing out the project. However, based on the connections created by this research that we noted above, we are opening a new project, focused on the investigation of “workaround cultures” in healthcare organizations. We have included a summary of this new project in our report under a separate title.

# The Impact of Burnout Contagion on Staff Job Performance in Hospital Departments

## Research Team

### Faculty

PI: Ben Dunford, Management, Kelly Wilson, Management, Louis Tay  
Department of Psychological Sciences

### Healthcare Partners

Spartanburg Regional Healthcare System, Spartanburg South Carolina;  
Providence Hospitals, Columbia South Carolina

## Research Direction

### Competencies

Organizational change and effectiveness  
Team dynamics, retention and engagement

### Research-to-Impact

Phase D (Multiple-site pilot study and evaluation)

### Research Timeline

August 2015 – August 2016

## Project Summary

### Healthcare Problem

Healthcare professionals have long suspected that burnout is highly contagious (i.e. transferable) between employees within teams and departments, and that burnout can aggravate entire work units as much as it does individuals (Glasberg, Norberg, and Soderberg 2007). Over 30 years ago, Edelwich and Brodsky (1980) observed that “if burnout only affected individuals in isolation, it would be far less important and far less devastating in its impact than it is. Burnout in human service agencies is like a staph infection in hospitals: it gets around”.

Unfortunately, no research that has examined the impact of shared burnout contagion on departmental functioning or staff job performance in hospitals. This lack of research on the consequences of department-level burnout is problematic for three reasons: 1) because departments are predominant features in healthcare organizational structures, 2) interpersonal dynamics within departments (e.g., interpersonal trust, communication, cooperation, goal setting, etc.) play a key role in the quality of healthcare delivery. 3) because existing burnout prevention and treatment strategies are almost exclusively designed to treat burnout as an *individual* phenomenon, rather than a shared, department contagion phenomenon. Thus, the effectiveness of burnout treatment initiatives may be augmented substantially by understanding the process by which individuals are influenced by the social dynamics of their work units or departments.

Thus, an understanding of departmental burnout and its effects on interpersonal dynamics and performance is a key aspect of improving healthcare delivery.

#### Research Objectives

1. Investigate how burnout contagion in hospital departments influences job performance of staff employees
2. Develop evidence based guidelines on how to reduce staff burnout and improve staff retention and job performance.

#### Methodology

Two large hospitals in the Southeastern US agreed to participate in this study by providing us with access to their deidentified personnel records and three deidentified employee engagement surveys conducted over a seven month period.

#### Potential Impact

If department level burnout contagion can be identified empirically as a cause of staff turnover and declined job performance, this could completely change how organizations treat and prevent burnout. Rather than treating individuals (as is current standard practice), healthcare organizations will have evidence based guidance for treating burnout as a collective phenomenon, with special attention to understanding how to prevent its spread within units in hospitals and other healthcare organizations.

## Workaround Culture in Hospital Organizations

### Research Team

Faculty	PI: Ben Dunford, Management
Students	Matthew Perrigino, Management
Healthcare Partners	Current Partner: Cameron Memorial Hospital  Potential Interested Partners: University of Iowa Health Care, IU Arnett, Community Health, Aurora Health, Dept. of Veterans Affairs, Good Samaritan, University of Wisconsin Health and Hospitals, UC Davis

### Research Direction

Competencies	Team Building / Dynamics
Research-to-Impact	Phase C (Single-site pilot study and evaluation)
Research Timeline	January 2016 – May 2017

### Project Summary

Healthcare Problem	While healthcare research has acknowledged the prevalence and problems of workarounds, the research has almost exclusively looked at it as an individual-level phenomenon. We are interested in exploring the notion of a workaround culture, which would imply that the organization, the supervisor, and co-workers help proliferate workarounds (as opposed to the individual-level antecedents which have commonly been explored). While individual-level analysis of quantitative data (e.g., employee surveys) is useful for diagnosing predictors of workarounds, our position is that workarounds will continue to persist unless there is a top-down effort from hospital administration teams to more systematically address this issue.
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### Research Objectives

All hospitals can make cultural improvements. However, our objectives are to pinpoint where and what improvements need to be made. We are particularly interested in whether why there are differences between departments (i.e., at the group level of analysis) in terms of the prevalence of workarounds. Is it varying degrees of workload, where some departments are extremely burdened compared to others? Is it the role of the department head or supervisor, where some are distrusted by their team while others are trusted? Are differences due to underlying differences in team dynamics, where the communication and cohesion of some teams is stronger than others? Is it a combination of these things,

where employees in certain departments feel more “psychologically safe” to raise awareness of issues because they are comfortable around both their co-workers and their supervisors? These are the types of questions our research seeks to answer.

### Methodology

Our methodology employs a mix of both qualitative and quantitative methods. First, we meet with the top management team (e.g., CEO, CNO, CFO, etc.) to learn about the pain points they suffer as an organization. Second, once their buy-in has been solicited, team building activities are conducted with the top management team to help build trust and camaraderie. Third, surveys are administered throughout the entire organization to create a diagnosis regarding the current state of the culture in the organization. Fourth, shortly after the surveys, employee interviews are conducted to supplement the survey data. Fifth, our research team summarizes the data and presents the issues to the top management team. During this presentation, the management team develops an action plan to implement cultural change based on the nature of what the diagnosis reveals. Finally, following the implementation of changes, follow-up surveys are conducted to determine the extent to which positive changes have been made in the organization.

### Potential Impact

The effective implementation of the project should result in a positive cultural transformation. More specifically, these results should manifest through a reduction in workarounds, in addition to improved employee morale, less employee burnout, and lower employee turnover. Subsequently, these improved outcomes for employees should result in benefits for patients and the overall organization.

### Project Update

We are currently collaborating with Cameron Memorial Hospital in Angola, IN, and have completed steps one through five of outlined in the “methodology” section above. To date, we have held multiple meetings with the administration team at Cameron, launched a survey, conducted more than 100 employee interviews, and helped the administration team develop an action plan based on the quantitative and qualitative data that were collected. The administration team is now in the process of disseminating the action plan to the hospital employees. We plan to launch additional surveys during the course of the next year to assess the change impact that the previous work has had.

Our goal is to roll out the same project to additional IPI-member healthcare organizations. IU Arnett and University of Iowa Health and Hospitals are among those organizations which have already expressed interest.

## Deskilling of Infusions in US Healthcare Facilities - REMEDI

### Research Team

Faculty	PI: Ben Dunford, Management
Students	Ben Pratt, Management; Ahmad Ashkanani, Management; Matt Perrigino, Management
Healthcare Partners	Infusion Nurses Society

### Research Direction

Competencies	Healthcare cost management, optimal job design
Research-to-Impact	Phase B (Research and model development)
Research Timeline	Survey and archival data collection beginning November 2015, extending through December 2016. Data analysis and write up of final paper, May 2017.

### Project Summary

Healthcare Problem	<p>Over the past 20 years, there has been a dramatic change in vascular access/infusion practices in US healthcare facilities. Technological advancements in infusion administration, paired with increasing economic competition for resources in healthcare facilities, have led many US healthcare institutions to disband expert infusion teams in favor of a primary care infusion model, in which primary care nurses administer infusions (which constitutes a process known as “deskilling”). Interestingly, this shift in infusion administration policies and practices has transpired during the same time that healthcare associated infections and other infusion related complications have become more common occurrences in US healthcare facilities.</p> <p>This project explores the vast array of infusion administration styles used by healthcare facilities in the United States. However, the primary purpose of this research is to examine the associations between infusion administration styles and negative clinical outcomes, such as healthcare associated infections. Additionally, this project will test a number of hypotheses regarding the impacts of healthcare management styles and workplace environments on infusion administration strategies adopted by US healthcare organizations.</p>
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### Research Objectives

1. Explore the infusion administration policies and practices across a large sample of US healthcare facilities.
2. Determine any relationship between infusion administration styles and negative healthcare outcomes
3. Determine the impact of management styles and workplace environments on infusion administration strategies within healthcare organizations in the US

### Methodology

In total, three online surveys will be conducted among all professionals affiliated with the Infusion Nurses Society. Sample size is approximately 10,000 nursing professionals across a large sample of healthcare institutions in the United States. These surveys use a variety of question formats, including open-ended, dichotomous, and Likert scale. These data will be combined with archival measures of infection rates, patient deaths and readmissions from the Centers for Medicare and Medicaid Services.

### Potential Impact

If significant relationships are found between infusion administration strategies and negative healthcare outcomes, the findings of this project could have a tremendous impact on infusion practice standards, which could potentially decrease the large number of healthcare associated infections typically attributed to infusions in US healthcare facilities. Additionally, the findings from this study may inform healthcare administrators regarding the potential impacts of management styles and workplace environment on clinical practices and outcomes.

## Lean Transformation and Organizational Change

### Research Team

Faculty	PI: Ben Dunford, Management
Students	Ahmad Ashkanani, Management
Healthcare Partners	Indiana University Health Physicians

### Research Direction

Competencies	Organizational development, lean management in healthcare
Research-to-Impact	Phase B (Research and model development)
Research Timeline	October 2015 – June 2016

### Project Summary

**Healthcare Problem**

Lean transformation emphasizes the importance of creating value and eliminating waste to the end users of the products and/or services offered by an organization. While lean transformation can help healthcare organizations with their quality improvement initiatives, such transformation process creates a disruptive change in the organization. Hence, it is important to understand how an organization can adapt through the transformation process while engaging its employees in the new process.

This project aims to document the lean transformation process at IU Health Physicians (IUHP) to understand what factors affect the implementation of the change process. This research opens the door to identify more research questions that may be used in future research studies.

### Research Objectives

1. Identify factors that help and hinder the implementation of the lean transformation process.
2. Based on lessons learned from the lean transformation process at IUHP, develop a set of best practices for other healthcare organizations seeking to make similar changes in implementing lean management in healthcare delivery.

### Methodology

We conducted a qualitative analysis by examining 892 comments made by physicians involved in the lean transformation process at IUHP. We developed a customized software system to analyze and code each of



the 892 comments into themes that relate to different organizational factors (e.g., training and development, leadership, team processes, etc.), lean processes and tools (e.g., value stream, Gemba, takt time, etc.), and different stakeholders within IUHP.

#### Potential Impact

Identifying the different factors that aid/hinder the lean transformation process can provide us with a set of best practices that would potentially help healthcare organizations to reduce unnecessary expenditures, improve patient wait times, and enhance patient satisfaction.

## Development of Physiological Monitor Databases - REMEDI

### Research Team

Faculty	Elisa Bertino, Computer Science
Staff	PI: Md Munirul Haque, Regenstrief Center for Healthcare Engineering Rich Zink, Regenstrief Center for Healthcare Engineering Peter Baker, CyberCenter
Healthcare Partners	Monitor Manufacturers: <ul style="list-style-type: none"><li>• GE Healthcare</li><li>• Philips Healthcare</li><li>• Draeger Medical</li><li>• Medtronic</li><li>• Spacelabs Healthcare</li></ul> Healthcare Providers: <ul style="list-style-type: none"><li>• Cameron Memorial Community Hospital</li></ul> Dissemination Partner: <ul style="list-style-type: none"><li>• Association for Advancement of Medical Instrumentation (AAMI)</li></ul>

### 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	Alarm hazards were identified as the number one hazard for 2014 by the Emergency Care Research Institute (ECRI). 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.
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## Bundled Payments

### *Research Team*

Faculty	PI: Steve Witz, Regenstrief Center for Healthcare Engineering Nan Kong, Biomedical engineering
Student	Simeng Qu, Statistics Zhouyang Lou
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 payers 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 health care 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) and hip replacement have been chosen for this research pertaining to providers' risk for accepting bundle payment reimbursement and mitigating this risk. Three years 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 total knee and hip replacement procedures have been identified by using CPT codes, ICD9 procedure codes and DRG codes from patients' claims.

Patients' data were edited to be consistent with bundled payment reimbursement methods established by CMS. Index procedures triggered an episode and were counted as an independent episode for analysis.

We define an episode as an index procedure occurring during the hospitalization during which the surgery was performed and including 30 days prior to admission and 90 days post hospital discharge. The total charge is the sum of four financial components: Service Paid Amount; Copay Amount; Deductible Amount; and Coinsurance Amount.

Our analysis yields total charge variations which are dramatic from episode to episode. This finding is consistent with CMS pilot projects on bundled payment reimbursement and has been reported as the basis for providers' assessment of large financial risk.

Our study is predicated upon the reporting from other studies that the inter-episode, total charge variance is not clinically justified and does not contribute to patients' outcome. This research has identified factors associated with inter-episode total charge variation and disseminated this information through CMCS to clinicians to seek their input options for care delivery changes to improve quality and reduce costs. We will model the changes recommended by these clinicians on the care delivery process and resulting inter-episode variation. We will also recommend changes to the bundled payment contracting methodologies where we believe the providers and purchasers of these episodes of care may mutually benefit.

The information derived from these models and contracting methodologies will be used to estimate providers' financial risk for bundled payment contracting for these two episodes.

This research is being extended to a broader patient population to determine if these findings have external validity to an extended population group. This extension requires additional data from a broader patient and provider population. For this research, an application for CMS data from ResDAC is being prepared.

## Advanced Engineered Diagnostics and Devices

### 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  
Voicu Popescu, Computer Science  
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  
Sthitapragyan Parida, Electrical and Computer Engineering

##### 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 (Multiple-site pilot study and evaluation)

##### Research Timeline

2014 – 2016

#### Project Summary

##### Healthcare Problem

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

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

### Research Objectives

The objectives are to:

2. 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;
3. 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 and refine STAR with corpsmen in cricothyroidotomy procedures on a human-patient simulator; and
5. 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

In the first version of STAR, the trainee tablet only approximates a transparent display effect. The video acquired by the tablet is displayed as is, without reprojecting it to the trainee's viewpoint. A simulated transparent display effect requires reprojecting the 3D geometry of the real-world scene to the trainee's viewpoint. Therefore, the color and geometry of the operating field, and the trainee's head position, must

be captured in real time and transformed to a common coordinate system. This information is acquired using a depth camera and a head tracker mounted on-board with the transparent display. This was the objective of the current reporting period of work.

During rendering, a color image from the tablet's onboard camera is initially acquired. Then, depth data is acquired as either a texture map or a point cloud, depending on the depth sensor used. The head tracker acquires the trainee's current head position.

From the depth map, a mesh is created that matches the real-world scene's geometry. In the case of holes in a depth map, which can appear in regions beyond the depth sensor's supported range or from dark or specular surfaces, a pull-push process is applied to fill holes with an average of nearby valid depth samples. When depth is acquired as a point cloud, the points are triangulated into a mesh in the display plane using Delaunay triangulation.

The mesh vertices are projected to the video frame to be assigned texture coordinates. The textured mesh is finally rendered from the trainee's viewpoint using the display as the image frame to create the transparency effect.



# Continuum of Wellness Progression and Patient Care

## Rating Healthcare

### *Research Team*

Faculty	Tzuong-tsieng Moh, Department of Mathematics
Staff	PI: Ping H. Huang, Regenstrief Center for Healthcare Engineering Ken Musselman, Regenstrief Center for Healthcare Engineering
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 pre-defined 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 health care 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 multi-criteria 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 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, for 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, non-weighted and non-linear approach, and ability to work with missing data.

### Project Update

#### \*\*\* PATENT PENDING \*\*\*

Based on a thorough review of the pairwise, comparison matrix methodology's usefulness, novelty, and non-obviousness, Purdue's Office of Technology Commercialization (OTC) submitted a provisional patent to secure the methodology's patentability and provide additional time to explore its commercial feasibility. The patent is still pending.

The methodology has now been extended to address absolute comparisons. This extension has been applied to two companies being serviced by OurHealth. See the project "Population Health Management to Support Accountable Care Delivery (Pilot: OurHealth)."

Other developments on this project include:

- A manuscript titled "A non-linear non-weight method for multi-criteria decision making " is still in review with the *Annals of Operations Research*.
- A presentation covering the OurHealth application of this methodology has been submitted to the *Healthcare Systems Process Improvement Conference 2016*, which is being held in Houston, Texas, on February 17-19.
- A presentation on "Assessing Company Wellness in Support of Accountable Care" has been submitted to the *IIE Annual Conference 2016*, which is being held in Anaheim, California, on May 21-24.

## Accountable Care Delivery (Pilot: OurHealth)

### Research Team

Faculty	Steve Witz, Regenstrief Center for Healthcare Engineering
Staff	PI: Ken Musselman, Regenstrief Center for Healthcare Engineering Ping Huang, Regenstrief Center for Healthcare Engineering Kit Klutzke, Regenstrief Center for Healthcare Engineering
Students	Hambisa Keno, Industrial Engineering
Healthcare Partner	OurHealth

### Research Direction

Competencies	Data analysis Modeling Stratification Interactive data exploration Cluster analysis
Research-to-Impact	Phase D (Multiple-site pilot study and evaluation)
Research Timeline	March 2014 – June 2016

### Project Summary

Healthcare Problem	<p>Increasingly, companies look to improve the overall health of their employees and associated dependents by making on-site healthcare clinics available. These clinics, which mainly provide primary care services, seek informed ways to:</p> <ul style="list-style-type: none"><li>▪ Manage their patients' health,</li><li>▪ Drive better health outcomes,</li><li>▪ More effectively integrate with other healthcare providers, and</li><li>▪ Decrease overall healthcare costs.</li></ul>
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RCHE is collaborating with OurHealth 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 assess the health of these communities and to identify medical management strategies that will improve the health of these communities. The process will leverage OurHealth's clinical

knowledge with claims and biometric information coming from OurHealth's patient population.

### Research Objectives

1. Evaluate data availability and technology opportunities associated with OurHealth functioning as an information source for clinical information.
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. Provide actionable steps that OurHealth can take in pursuit of 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 OurHealth's systems to drive decision support methodologies, filtering the elements as appropriate. Conduct healthcare analytics to learn how to best address OurHealth's on-site care environment and then work with OurHealth to understand the appropriateness and usefulness of various approaches in determining targeted medical management strategies for this population.

### Potential Impact

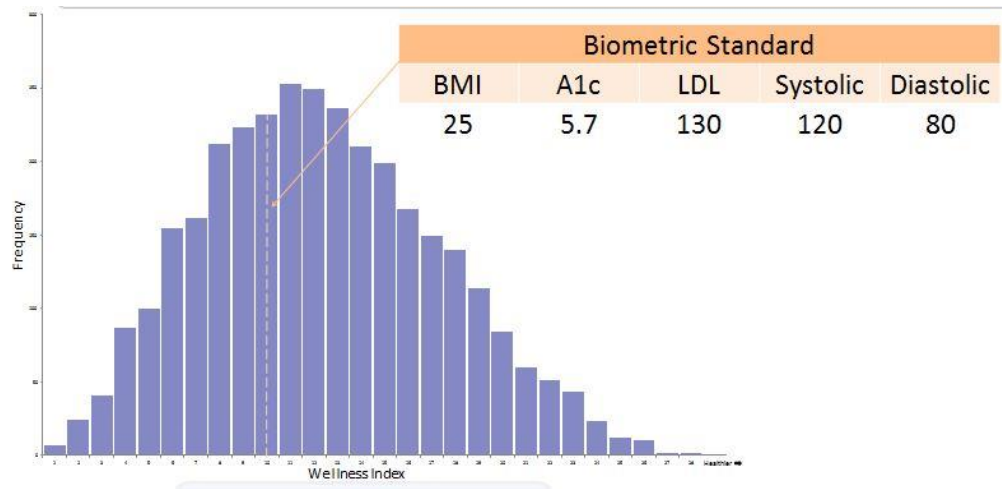
To improve accountable care delivery effectiveness through the improved selection and adoption of clinic-specific management.

### Project Update

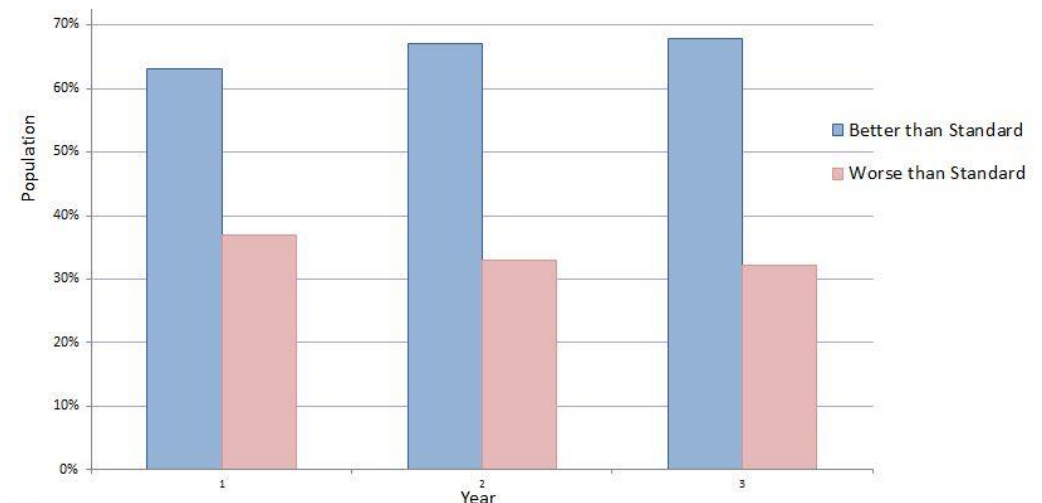
Previously, a comparative analysis using OurHealth's biometric data was conducted using three methodologies: Score, Appraise and Compare. The Compare method, which uses a matrix-based ranking technique that was developed at RCHE, showed a number of significant advantages. These advantages included a better ability to scale (both number of criteria and population size), address missing data, discriminate, and handle non-linearity.

Then, as a more comprehensive test of the technique, the research team examined two companies being serviced by OurHealth. Over a 3-year period, more than 10,000 patients were evaluated. In spite of having a significant number of missing biometric values in the population set, the Compare method performed very well.

Wellness trend analyses over this timeframe showed both relative and absolute improvement for both companies. As an example, the first graph below shows the distribution of the patients' wellness index against a biometric standard for one of these companies. The second graph reveals the yearly improvement in overall company wellness based on the patients' biometrics for this same company.



Patient Wellness Histogram



Percent of Population Better/Worse than Standard by Year

## Accountable Care Delivery (Pilot: St. Vincent Health)

### Research Team

Faculty PI: Steve Witz, Regenstrief Center for Healthcare Engineering

Staff Kit Klutzke, Regenstrief Center for Healthcare Engineering  
Jennifer Hill, Regenstrief Center for Healthcare Engineering

Students Mina Ostavari, Industrial Engineering  
Simeng Qu, Statistics  
Shan Xie, 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 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; and
- Disseminate findings for generalization when appropriate to other populations to enhance population health management knowledge and practices.

### Methodology

Statistical analyses

### Potential Impact

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

### Project Update

The data being utilized in this research has been expanded to include, and integrate, claims data for services provided at the work site clinics, services provided by non-work site providers, health risk appraisal information and an exercise program sponsored by one of the employers.

Analyses providing descriptive information pertaining to population members, their activity in their employer's health plan, the prevalence of conditions present in the populations, and services population members have utilized has been completed. The patterns of utilization by members of the populations have been assessed to provide detailed analyses of utilization by population members characterized by demographic and condition variables.

This information has been provided to the work site clinic leaders and is being reviewed.

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. Alternative care delivery practices are being evaluated with preparations underway to present options to the respective employers. Employers and healthcare providers will review options for population health management plans. This review will identify the first series of population health management strategies to be implemented.

In the course of this project, research methods pertaining to the organization and analyses of claims data, interpretation of primary and secondary diagnoses to measure population disease prevalence, and prioritization of medical management strategies have been developed that may contribute to other population health research utilization claims data. Additionally, analytics have been established that will evaluate the extent to which population health management practices are consistent with evidence-based care guidelines for prevalent and/or high cost conditions.



# Transitions in Care Pilot: Evaluate the Impact of Electronic Communications

## *Research Team*

### Faculty

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

### Students

Shan Xie, Industrial Engineering  
India Bergeland, DURJ 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 – December 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. Previous reported research documents 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.
4. Identify factors underlying provider adoption and use of communication technologies supporting care transitions.

### 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 30-days post-hospital discharge. Second, semi-structured interviews are conducted with hospitals and skilled nursing facilities (SNFs) to collect data to evaluate the information transfer process pre and post-implementation of electronic communications in terms of content, format, timeliness, cost, and security. Timestamp 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 are being measured through online survey methods in collaboration with MHIN.

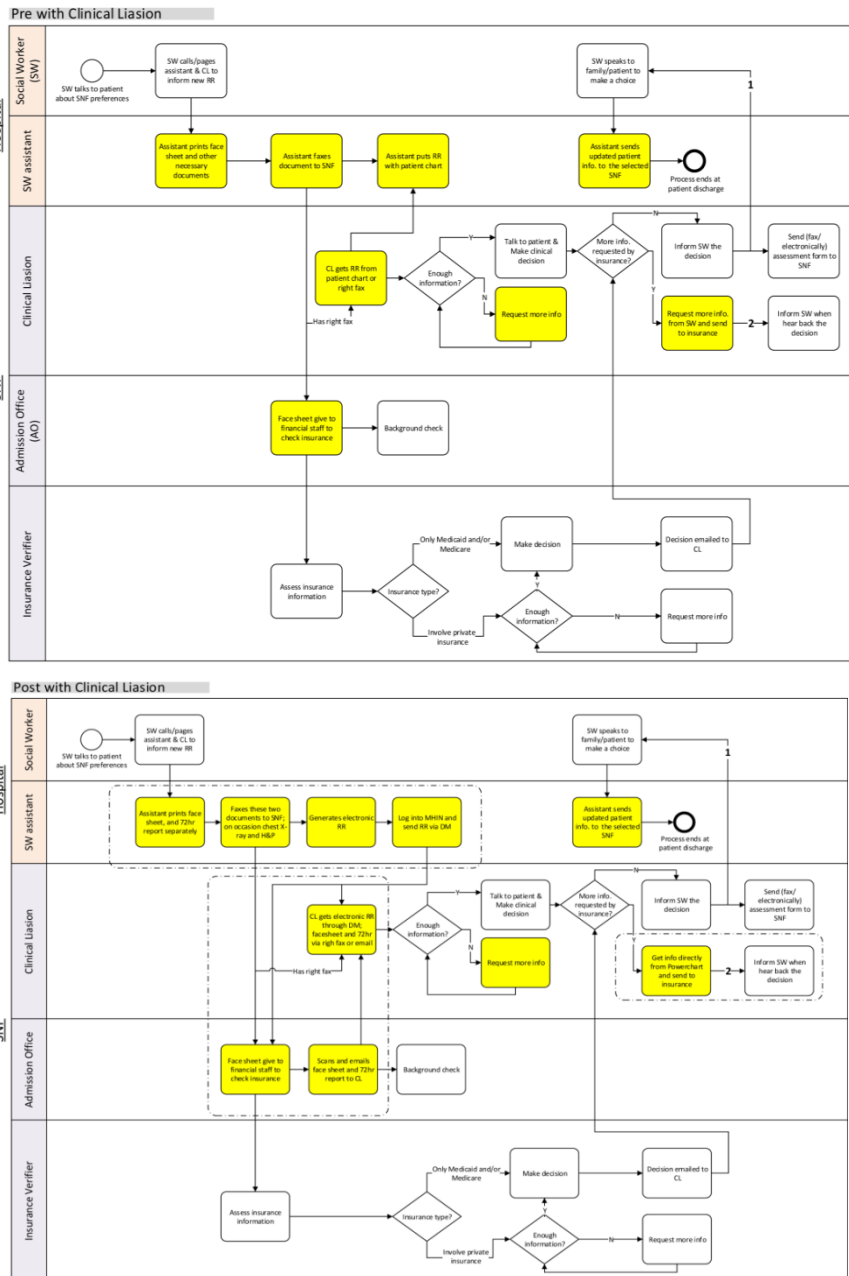
### Potential Impact

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

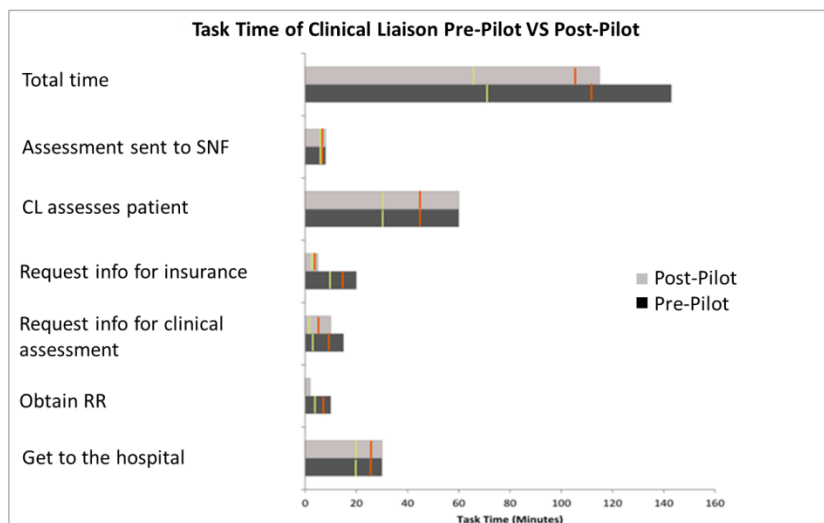
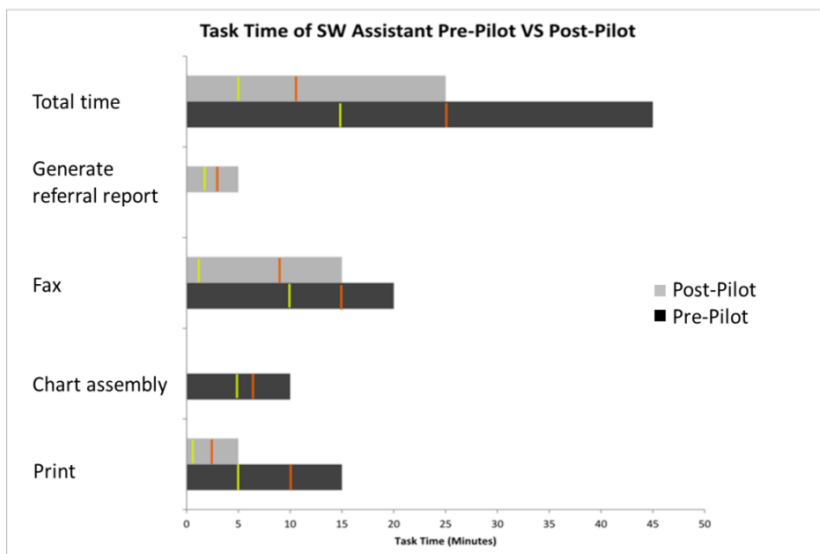
1. Increased provider satisfaction with the availability and quality of clinical information, and
2. Improved patient outcomes (e.g., a reduction of hospital readmissions among patients discharged to a SNF or LTPAC facility).
3. Identification of strategies for improving meaningful use of communication technologies.

### Project Update

IRB approvals have been granted for existing data, interview, and survey. Data collection for survey will begin in May 2015. Ten interviews were conducted with hospital and skilled nursing facilities. Initial surveys to SNS and physician partners have been delivered and initial responses are being analyzed. The referral process pre and post-implantation of electronic communications were 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 social worker assistant and clinical liaisons, the time that takes to finish each step were 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 and search for fax machine) and clinical liaisons from SNFs.
2. Information is readily accessible. Clinical liaisons are less dependent on social workers and their assistant.
3. Social worker can spend more time with patients without being interrupted by others seeking 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 wrong person pick up the fax, loss of information and potential breach of patient information privacy.

Beside the benefits, there are some potential improvements to the current system that 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 call back information to be entered rather than rely on the sender to include the information.
5. Improve the reliability of the system.
6. Make sure everyone fully understand the functionality of the tools.
7. Provide consistent training and support.
8. Conduct regular user evaluation, and encourage feedback and critiques.

## Wellness Coaching Impact on Employee Health Outcomes

### Research Team

Faculty	PI: Bart Collins, Communication
Students	Heather Fedesco, Communication Wan Jiang, Science Yao Tang, Statistics
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)

### 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 of 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 of 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 datasets formed the basis of successfully defended dissertation in May from the Brian Lamb School of Communication by Heather Fedesco entitled: "Employee wellness coaching as an interpersonal communication intervention: Exploring intervention effects on healthcare costs, risks, and behaviors." Project is closed with manuscripts under development for publication.

# Interventions to Improve Type 2 Diabetes (T2DM) Adherence & Outcome in Rural Indiana: A Randomized Controlled Trial

## Research Team

Faculty	PI: Cleveland Shields, Human Development and Family Studies Elliot Friedman, Human Development and Family Studies Stewart Chang Alexander, Consumer Science
Staff	Poching DeLaurentis, Regenstrief Center for Healthcare Engineering
Students	Phanlada Chatha-Hill, Health and Kinesiology Lindsay Fuzzell, Human Development and Family Studies
Healthcare Partner	Indiana Rural Health Association (IRHA)  Fayette Health System, Connersville, IN  Rush Memorial Hospital, Rushville, IN

## Research Direction

Competencies	Randomized Controlled Design
Research-to-Impact Phase	Phase B (Research and model development)
Research Timeline	May 2015 – December 2015

## Project Summary

Healthcare Problem	Type 2 diabetes affects more than 29 people in the US (Guariguata et al., 2014) and increases risk of premature death (Rao Kondapally Seshasai et al., 2011) often due to non-adherence to medication and behavior change recommendations. Type 2 diabetes prevalence is higher in adults living in rural areas compared with those in urban areas (Mainous, King, Garr, & Pearson, 2004; O'Connor & Wellenius, 2012). Many factors contribute to rural diabetes non-adherence such as distance to healthcare, less educated population, scarcity of providers and pharmacists, and a more impoverished and elderly population (Clark, 2014; Krishna, Gillespie, & McBride, 2010), Urtz, 2008). Due to these barriers, as well as personal obstacles (e.g. motivation or memory to take medications), and psychosocial, educational, and cultural barriers (Lerman, 2005), non-adherence is a significant impediment to diabetic control in rural populations.
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This project supports the community work required to prepare a Community Based Participatory Research designed to improve Type 2 Diabetes adherence and bio-medical outcomes.

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

#### Research Objectives

To conduct a pilot RCT (R21) to support development of either an R01 NIDDK or PCORI follow-up application.

The pilot will test the feasibility of the intervention and estimate effect sizes for a fully powered trial.

#### Methodology

PCORI methodology standards require us to develop interventions, outcomes, processes and all research plans in collaboration with community partners. PCORI does not fund pilot work, so we are first pursuing funding from NIDDK. 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 is comprised on 30 hospitals and has a presence in virtually every rural county in Indiana. Writing and submitting this NIDDK 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 and the NIDDK application is 80% written and consultation with two rural health systems are ongoing.

# All-Cause Unplanned and Preventable Readmissions Reduction

## Research Team

### Faculty

Lingsong Zhang, Statistics  
Karen S. Yehle, Nursing

### Staff

PI: Ken Musselman, Regenstrief Center for Healthcare Engineering  
Benjavan Upatising, Regenstrief Center for Healthcare Engineering  
Kit Klutzke, Regenstrief Center for Healthcare Engineering  
Rich Zink, Regenstrief Center for Healthcare Engineering

### Students

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

### Healthcare Partner

Cleveland Clinic

- Main Campus
- Fairview
- Hillcrest
- Marymount
- South Pointe
- Lakewood
- Medina
- Lutheran
- Euclid

## Research Direction

### Competencies

Data Mining  
Statistical Analysis  
Project Management

### Research-to-Impact

Phase D (Multiple-site 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 in order to reduce unnecessary 30-day readmissions, healthcare utilizations and cost of care.

### Project Update

The research team has the following publication under review with the *Journal of General Internal Medicine*:

"All-Cause Unplanned 30-Day Hospital Readmission Prediction Model," Benjavan Upatising, PhD; Kenneth J. Musselman, PhD; Nancy M. Albert, PhD, CCNS, CHFN, CCRN, NE-BC, FAHA, FCCM; Donglai Chen; and Michael W. Kattan, PhD



# **Publications**



## Selected Publications 2015

(Bolded names identify RCHE Faculty)

- Bechar, A., Nof, S. Y., & **Wachs, J. P.** (2015). A review and framework of laser-based collaboration support. *Annual Reviews in Control*, 39, 30-45. doi: 10.1016/j.arcontrol.2015.03.003.
- Dunford, B. B.**, Jackson, C. L., Boss, A. D., Tay, L., & Boss, R. W. (2015). Be Fair, Your Employees Are Watching: A Relational Response Model of External Third-Party Justice. *Personnel Psychology*, 68(2), 319-352. doi: 10.1111/peps.12081.
- He, S., Craig, B. A., Xu, H., Covinsky, K. E., Stallard, E., **Thomas, J.**, Sands, L. P. (2015). Unmet Need for ADL Assistance Is Associated With Mortality Among Older Adults With Mild Disability. *The Journals of Gerontology Series A: Biological Sciences and Medical Sciences*, glv028.
- Hertig, J. B., & **Degnan, D.** (2015). Safety perspectives on informatics. *American Journal of Health-System Pharmacy*, 72(8), 616-616. doi: 10.2146/ajhp150155.
- Kang, Z. H., & **Landry, S. J.** (2015). An Eye Movement Analysis Algorithm for a Multielement Target Tracking Task: Maximum Transition-Based Agglomerative Hierarchical Clustering. *Ieee Transactions on Human-Machine Systems*, 45(1), 13-24. doi: 10.1109/Thms.2014.2363121.
- Li, Y., **Kong, N.**, Lawley, M., Weiss, L., & Pagán, J. A. (2015). Advancing the Use of Evidence-Based Decision-Making in Local Health Departments With Systems Science Methodologies. *American Journal of Public Health*, 105(S2), S217-S222.
- Melton, K. D., Foli, K. J., **Yehle, K. S.**, & Griggs, R. R. (2015). Heart Failure in Hispanic Americans: Improving Cultural Awareness. *The Journal for Nurse Practitioners*, 11(2), 207-213.
- Menon, J., & **Thomas, J.** (2015). Association between Osteoarthritis and Workplace Absenteeism. *Value in Health*, 18(3), A163-A163.
- Mishra, P., & **Thomas, J.** (2015). Pharmacy Directors' Perceptions of Administrators' and Health Professionals' Attitudes Towards Collaborative Drug Therapy Management (Cdtm) in Us Hospitals. *Value in Health*, 18(3), A91-A92.
- Pereira, A., **Wachs, J. P.**, Park, K., & Rempel, D. (2015). A User-Developed 3-D Hand Gesture Set for Human-Computer Interaction. *Human Factors*, 57(4), 607-621. doi: 10.1177/0018720814559307
- Perrigino, M. B.**, & **Dunford, B. B.** (2015). The unique effects of general and specific support in health care technology: An empirical examination of the principle of compatibility. *Health care management review*.
- Upatising, B.**, Wood, D. L., Kremers, W. K., Christ, S. L., **Yih, Y.**, Hanson, G. J., & Takahashi, P. Y. (2015). Cost Comparison Between Home Telemonitoring and Usual Care of Older Adults: A Randomized Trial (Tele-ERA). *Telemedicine and e-Health*, 21(1), 3-8.

Yang, X. Q., Sanders, K. N., Mardekian, J., Mychaskiw, M. A., & **Thomas, J.** (2015). Associations Between Sildenafil Use and Changes in Days of Hospitalization in a Population With Pulmonary Arterial Hypertension Associated With Connective Tissue Disease. *Clinical therapeutics*, 37(5), 1055-1063. doi: 10.1016/j.clinthera.2015.02.025.

Zhang, S., & **Thomas, J.** (2015). Adherence to Chronic Obstructive Pulmonary Disease Maintenance Medication among Patients with Copd. *Value in Health*, 18(3), A177-A178.