RSNA R&E Foundation Education Scholar Grant
Education Scholar Grant Application

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NOTE: Personal information for the applicant and other investigators has been removed from this sample application.

Title: Development and Implementation of a Radiology Improvement Leader Training Course

Abstract:

Healthcare is fundamentally changing and many of these changes are driven by the need to improve healthcare's value, quality and safety. To play a role in this future, radiology's upcoming leaders must not only learn the scientific basis of process improvement but also gain experience in running process improvement projects. To address this need, we plan to create the Radiology Improvement Leader Training Course (RILTC). The RILTC will be based on a proven model, the Improvement Advisor Program developed by the Institute for Healthcare Improvement (IHI). The Principal Investigator (PI) is currently enrolled in the IHI program and will complete it in May 2012. The PI will combine his expanded knowledge of process improvement strategies with his experience in curriculum development to develop and lead the RILTC. The 2012-13 version of the RILTC will enroll 10 trainees who will conduct their own process improvement projects and concurrently learn the fundamental principles behind both process improvement and change management. Trainees will include all members of the radiology team: physicians, nurses and technologists. Together they will learn to develop project charters, run improvement cycles, analyze their results using tools from statistical process control and report their progress. The RILTC will also include numerous opportunities for assessment, feedback, and group learning. These assessments will guide efforts to improve the course. The project's short term goals are to create the curriculum, train the first class and learn how to improve the course. The intermediate goal is to build a scalable program which can be implemented by the greatest number of institutions. The long term goal is to expand the program and thereby position radiology as a leader in healthcare's future.

Percent of Time Dedicated to this Project:

As Chief Quality and Safety Officer at the Mallinckrodt Institute of Radiology and Medical Director of Vascular Access at St Louis Children's Hospital, Dr. Duncan oversees process improvement methods to common medical procedures. These efforts are included in the allocations below. *20% RSNA Education Scholar *50% Clinical Service efforts *30% Teaching/Educational efforts.

Priority Statement:

Data-driven process improvement has been my priority and passion since 2004. During the past 7 years, I have built systems designed to optimize radiation use, improve team performance during the preprocedure timeout and reduce central line associated bloodstream infections. This work leverages my background in basic science and increasing utilizes process improvement strategies. This RSNA Education Scholar application will establish a formal course that highlights the radiology perspective. This course will be based on the highly successful Improvement Advisor Program created by the Institute for Healthcare Improvement (IHI).

The IHI curriculum emphasizes four aspects of successful projects: systems thinking, building knowledge, understanding variation, and appreciating the human side of change. My PhD research in molecular biology and postgraduate work in receptor-targeted imaging agents taught to think about the overall system. That included not only how the agent might reach and bind to its target but also the subsequent endocytosis and metabolism (Duncan 1993, Franano 1995). We used multiple cycles of prediction, data collection, and analysis to construct a comprehensive model (Duncan 1997). In the lab, we built knowledge by starting with an hypothesis and designing experiments that provided the data needed to test those predictions. In contrast, clinical work too often bypasses these steps. As the flood of data from electronic medical records grows, the focus seems to have shifted towards acquiring and cataloging data rather than creating and testing predictions (Duncan 2009). Clear examples were evident when my group began examining fluoroscopic procedures in detail. Research in how humans learn to process information and our work with simulation-based training convinced us that fluoroscopic interventions depended on a series of intraprocedural decisions where each decision should be preceded by prediction, data acquisition and analysis (Duncan 2007). Our analysis of recorded procedures also demonstrated how patients were frequently exposed to more ionizing radiation than was needed to answer the question at hand (Beta 2009). The IHI framework is based on the work and philosophy of W. Edwards Deming. Deming emphasized the importance of using statistical tools to help decide whether any observed deviation from prediction resulted from random variation or a causal event. These ideas form the theoretical basis of statistical process control and they overlapped with topics I had learned when studying statistical mechanics and enzyme kinetics. Further study into human decision making led me to Fitts' Law and it links to Claude Shannon's work on the mathematical basis of communication. Shannon described how any message's informational content could be analyzed using statistics and how information is defined by its ability to reduce uncertainty. My group incorporated these ideas about variation, information, and entropy into our work (Duncan 2008, Bucholz 2009, Jacobs 2009, Beta 2012).

The IHI framework also appreciates the human side of change. In 2008, my roles changed since not only was I asked to lead the department's quality and safety efforts but I was also charged with heading the interventional radiology (IR) service at St Louis Children's Hospital (SLCH). This was a unique opportunity to apply quality/safety principles to the redesign of a clinical service. Since we had just demonstrated the utility of recording patient procedures, we were able to convince the hospital's leadership that the new pediatric IR suite should include a permanent recording system (Jacobs 2010). This system has been used to record every IR procedure and those recordings have been a valuable asset to our efforts to build a team of technologists, nurses and physicians. From the outset, we recognized that the preprocedure timeout was a common task that epitomized teamwork. For the last three years, we have used improving timeout performance as a team building exercise. The timeout project not only uses the recordings to audit compliance with our timeout protocol but also provides the data we need to improve our preprocedure checklist. This ongoing project was recognized as an outstanding Quality Storyboard during the 2010 RSNA Annual Meeting and won an AHRA 2011 Best Practices in Radiology Quality and Economics Award. Recent efforts to improve our timeout scoring system will be a featured abstract at the 2012 Society of Interventional Radiology Annual Meeting.

Senior leadership at the Washington University Medical Center now views radiology as a quality/safety leader. When my 2011 RSNA Education Scholar Grant was not selected for funding, they provided the financial support I needed to enroll in the IHI Improvement Advisor program. They also selected optimizing radiation exposure as a keynote topic for the 2011 Annual Patient Safety Conference. They recently asked me to lead the committee which oversees SLCH's quality and safety activities. This last activity provides regular interactions with the SLCH Board of Directors.

My experiences convince me that radiology can play a central role in the national quality/safety agenda. Moving forward and sustaining our prior gains will require developing future leaders who fully understand the scientific nature and practical aspects of process improvement. My background convinces me that leadership development is a multistep process that starts with trainees and frontline staff. The Mallinckrodt Institute of Radiology is fortunate to have one of the largest and most successful training programs in the country. Our trainees go on to successful careers in academic centers and community hospitals throughout the nation. The Radiology Improvement Leader Training Course will be a step towards establishing a shared mindset around radiology's approach to process improvement.

The curriculum and training materials developed during this RSNA Education Scholar Grant will be available online so that other training centers might build upon them. My work with the RSNA Quality Improvement Committee, the Society of Radiology Foundation and the American Board of Radiology Foundation demonstrates the clear advantages of developing open source tools for quality/safety improvement.

My goal is to foster a learning community which continually renews and reinvents itself.

Budget: (*Budget details have been removed from this sample*)

Project Timeframe: 7/1/2012 – 6/30/2013

Total Project Budget: $75,000

Amount Requested: $75,000

Complete Budget Justification

A.	Personnel	
	James R. Duncan, MD PhD, Principal Investigator, salary support X% effort	$ Y
	Mandie Street, RT, Clinical Research Coordinator, X% effort	$ Y
	Biostatistics Service Fee:	$ 1,500
	Stasticial services: data analysis ($50 x 30 hours)	$ 1,500
B.	Supplies:	$ 1,454
	Textbooks required for courses/class - online learning/Subscription:	$ 2,000
C.	Other (none)	

Other Investigators:

Mandie Street, RT, Clinical Research Coordinator

Detailed Education Plan: **(See Next Page)**

School of Medicine is ranked first for student selectivity among US medical schools; the residency programs are consistently ranked in the top ten. The medical school class ranges in size from 120-130 students per year.

The St Louis Children's Hospital Interventional Radiology Suite:
Recordings will take place in this new suite which opened in November 2008. The suite is located on the 7th floor of St Louis Children's Hospital near the Cardiac ICU, Pediatric ICU and Operating Rooms. The suite is equipped with a state-of-the art Siemens Artis angiography unit which includes a series of features for reducing radiation dose. The suite contains a Zonare ultrasound unit which is capable of recording video sequences of the ultrasound images. The suite is also equipped with an audio and video recording capability that includes two Pan/Tilt/Zoom video cameras which provide an overview of the room, a boom mounted camera which can be moved over the field to obtain detailed views of the operators' hands, a direct feed of the fluoroscopy image from the Siemens Artis unit, and two microphones. These datastreams are routed to a B-Line Medical SimCapture device which is capable of recording the fluoroscopy image in full resolution (1280x1024) together with content from two of the room cameras. The SimCapture recordings are now routinely matched up with data extracted from the DICOM-SR files. DICOM-SR files are available from the pediatric IR suite, two adult IR rooms and one of the neurointerventional rooms. At the end of each procedures, the equipment automatically sends the resulting DICOM-SR file to a central server. The resulting dataset now includes more than 2500 procedures.

The Mallinckrodt Quality/Safety Office and Simulation Laboratory:
Portions of this data will be analyzed in our two room 499 square foot suite which opened in July 2008. This suite is centrally within the Mallinckrodt Institute of Radiology near the South Campus Interventional Radiology angiography suites and physician offices. The suite includes office space (220sq) devoted to data processing and content creation. The suite also includes a 279 sq foot lab which houses equipment for hands-on simulation. This includes the Mentice VIST, a virtual reality angiographic simulator. This lab also houses the ultrasound simulator including a Sonosite iLook portable ultrasound unit, Northern Digital Aurora electromagnetic tracking device and a series of ultrasound phantoms. The room is equipped with audio-visual equipment (camera, digital/analog converters, scalers, switches and recorders). The suite also includes storage space for files as well as the catheter/guidewire skill task trainers when they are not being used by trainees.

Washington University School of Medicine (WUSM). WUSM has a rich history of success in research, education and patient care, earning it a reputation as one of the premier medical schools in the world. Since its founding in 1891, WUSM has trained nearly 6,000 physicians and has contributed groundbreaking discoveries in many areas of medical research. WUSM is internationally recognized for major research contributions in neuroscience, genetics, diabetes, cardiovascular diseases, oncology, immunology, diagnostic imaging and many other areas. The School currently has 1,435 full-time faculty.

Mallinckrodt Institute of Radiology (MIR). MIR is headquartered in a 13-story structure supplemented by several satellite facilities, with a total of more than 350,000 sq. ft of space. There are 74 examination rooms available to MIR faculty to provide all diagnostic and therapeutic radiology services needed for the Medical Center. MIR is one of the largest radiological facilities in the world, possessing state-of-the-art instrumentation, and has the capacity to perform studies with all relevant imaging technologies, including ultrasound, CT, MRI, PET, digital radiography, and digital subtraction angiography. The MIR faculty are dedicated to clinical care, teaching, and research. The MIR staff includes 186 academic faculty (100 physicians, and 76 Ph.D. and 10 M.S. scientists).

Pertinent details for this project include the Radiology Information System (RIS) which is used to track all procedures within the department. The RIS was updated in June 2010 and now allows the Quality and Safety Office to readily extract radiation metrics from every CT and fluoroscopic procedure performed at the institute. Data capture capability will expand as new data mining tools such as RADIANCE and DICOM-SR dose reports are brought online. St Louis Children's Hospital (SLCH). SLCH is a 250-bed non-profit teaching hospital dedicated to the treatment of pediatric patients. St Louis Children's Hospital of more than 300 member medical staff includes full-time faculty of Washington University as well as private physicians. The medical staff is supported by a house staff of more than 80 residents, interns and fellows, in addition to professional nurses, technicians, and service and support personnel. SLCH is fully accredited by the Joint Commission on Accreditation of Healthcare Organizations.

Computer:
Computing and Network Resources
The MIR Quality/Safety Office and Simulation Lab has ample computer hardware and software resources. The Quality/Safety Office has 4 computer workstations available for this project and two of them are equipped with Adobe Creative Suite 5 Master Collection software which includes the Premiere Pro video editing software as well as professional level software for DVD creation (Encore), audio manipulation (Soundbooth), still image processing (Photoshop), vector based drawing (Illustrator) and an electronic learning tool (Captivate). Software resources also include data analysis and presentation tools (Access, Excel,
Sigmaplot, Minitab, XFMEA).

In addition to the list above the suite offers external storage availability, equipment and supplies for authoring CD's, DVD's, including BluRay and Lightscribe capabilities.

A. DETAILED EDUCATION PLAN

A.1 INTRODUCTION A.1.1 Rational and Purpose:

General Statement of Purpose:

Radiology's future leaders must learn process improvement techniques so that they can better lead frontline teams as they conduct quality/safety improvement projects. Our current training programs do not yet foster these skills and thus we propose creating a Radiology Improvement Leader Training Course (RILTC). The RILTC curriculum will be based on the highly successful Improvement Advisor Program developed by the Institute for Healthcare Improvement (IHI). The PI will soon complete the IHI Improvement Advisor Program (IHI IA Program) and will use that knowledge to craft the RILTC curriculum and lead the course.

Why does radiology need such a training course?

Medicine has a quality problem.[1] Hospital acquired infections, wrong patient/wrong site procedures and excess exposure to ionizing radiation have all attracted the public's attention. Radiology will either become part of the solution or risk fading into the background.[2, 3] Although Image Gently and other initiatives have led to some changes, the public and oversight agencies such as The Joint Commission, CMS, and FDA will increasingly demand objective evidence of improvement. The future of our specialty will depend on developing leaders who understand the scientific basis of process improvement, and can guide frontline teams to success during data-driven projects. While the change concepts behind Lean Sigma, Plan Do Study Act (PDSA) cycles and other process improvement strategies might be familiar to anyone who has studied the scientific method, our future leaders will require additional skills. The IHI IA Program is based largely on the work and philosophy of W. Edwards Deming.[4, 5] He described four key elements of successful improvement efforts (Table 1). Although some future leaders might acquire these skills through their own initiatives or happenstance, we contend that an organized curriculum based on the IHI's proven model will be the most effective means of rapidly improving radiology's quality and safety efforts.

Table 1: Deming's Approach to Process Improvement	
Appreciation for a system	Understanding variation
Building Knowledge	Human side of change

Deming described his approach as a "Theory of Profound Knowledge" since it combined building knowledge with systems thinking, predictive statistics and human psychology.[6]

Some might suggest that radiology could train its future leaders using existing venues such as the IHI IA Program. However, the costs of this course are substantial since tuition is $16K and it requires three separate trips to Boston for 12 days of face-to-face sessions over a 10 month period. Others will suggest that a 3 day weekend course should provide sufficient training. The reality is that acquiring new skills requires time and practice.[7] For example, even though our Ob/Gyn colleagues already possess considerable knowledge about pelvic vascular anatomy and the pathophysiology of uterine leiomyomas, few interventional radiologists believe that complex techniques like uterine fibroid embolization can be mastered during a weekend course. A rigorous approach to process improvement is no different. Mastering the necessary techniques requires time and what Ericsson terms "deliberate practice".[8, 9]

A.1.2. Objective

This project's long term objective is to begin training future leaders so that they understand the scientific basis of process improvement and can apply this knowledge to the issues confronting radiology. Although this one year project will focus on establishing a prototypical training program at a single institution, our goal is to build a scalable program which can later be implemented at the greatest number of institutions.

A.1.3 Student Population: What learner group(s) will be served by the project?

The RILTC's target population is the physicians, nurses and technologists who serve on radiology's frontline teams and are interested in learning process improvement techniques. Initially, course enrollment will be limited to 10 trainees since the curriculum requires each participant to present their project charter, a PDSA cycle, leadership report and final summary to their classmates. The initial course will focus on interventional radiology (IR) since that will best leverage our current data capture methods, existing online training materials and the subject matter expertise. Plans for future expansion are described in Section A3.2.

A.1.4 Previous Experience: Relevant preliminary work/prior experience of investigator

Experience with process improvement

Prior sections (Priority Statement and Biosketch) describe the PI's background in process improvement. This section will concentrate on the PI's participation in the IHI IA Program. The IHI IA Program is designed for participants who are already working in process improvement and want to deepen their knowledge and enhance their effectiveness. As part of the IHI IA Program application, participants propose a project that they will direct during the program. This project provides two benefits: 1) a chance to achieve meaningful results; 2) a learning laboratory. The IHI enrolls approximately 20 Improvement Advisors (IAs) every 6 months and the PI was accepted into the 21st iteration of this course. He will be the first IHI IA Program graduate to return to a radiology department. The IHI IA Program includes three four-day learning and working sessions, as well as a series of monthly homework assignments. The IHI's faculty host monthly webinars and provide individualized coaching. Participants are also paired with one another to provide opportunities to review their classmates' work products and provide feedback. Participants are expected to devote 12 hours a week to the training.

The primary aim of the PI's IHI IA project is a 50% reduction in patient exposure to ionizing radiation from fluoroscopic procedures over a single year (5/11-5/12). The PI and his team have configured 4 IR suites to send DICOM structured reports to a central server and are using this data to monitor radiation exposure. As part of the IHI IA Program, the team has also learned to use statistical process control software (Minitab 16). That analysis finds that the PI's IHI IA project is ahead of schedule.

Experience with curriculum development and implementation

The PI and his team already have substantial experience with curriculum development.[10] We used Failure Mode and Effects Analysis (FMEA[11-13]) to identify strategies for preventing retained guidewires and catheter related bloodstream infections (CLABSIs). We then created a series of web-based and hands-on simulations. These have been used to train more than 650 new interns over the last 5 years. Our course has advanced to the stage where on-line modules allow trainees to learn skills without an instructor and the hands-on modules are often taught by prior students who follow a predetermined script. The course is credited with decreasing the frequency of retained guidewires and CLABSIs.[10] This training also includes a series of online assessments that leveraged our expertise with assessment design.[14-17] We recently extended that work and reported the domain, task and evidence models needed to monitor skill development in ultrasound guided procedures.[18] In the last 8 months, we have been analyzing the DICOM structured reports and video recordings from the pediatric IR suite at SLCH to identify and prioritize failure modes that increase radiation exposure.[19, 20] This radiation exposure FMEA has become one of the key drivers behind our efforts to optimize radiation use.

A.2 PROJECT PLANS:

A2.1 Objectives: The project will achieve its objectives by completing the following tasks:

1. Design the curriculum and enroll trainees
2. Collect/create the training materials and present them to trainees in a structured manner
3. Assess the curriculum's effectiveness

A.2.2 Activities: What specifically will be done to achieve the above objectives?

A.2.1.1. Design the curriculum

The RILTC's curriculum will follow the frame used for the IHI IA Program. Trainees will not only attend didactic sessions but also propose a process improvement project, complete a series of homework assignments and periodically report their progress. The completed assignments will be presented to the course faculty and distributed to other trainees for feedback. Each trainee will present their project charter, the results of a PDSA cycle, leadership report and final project summary to the entire group.

When compared to participants in the IHI IA Program, RILTC trainees will not have the same degree of experience with process improvement techniques. This fact, as well as the need to begin the course early in the academic year, means that trainees will be encouraged to choose their 2012-13 process improvement topic from a list rather than creating them *de novo*. These projects will leverage our experience with data collection and minimize the paralysis that often accompanies new initiatives.

Table 2.1 Potential Process Improvement Topics for 2012-13*	
1	Radiation use during common procedures (eg UFE, intraperitoneal abscess drainage, IVC filter placement
2	Workflow issues such as first case start time and discharge process
3	Catheter associated bloodstream infections
4	Timeout performance
5	Unplanned repeat procedures (earlier than expected abscess catheter replacement, dialysis intervention, readmission following chemoembolization, etc)
*This is not a complete list since it focuses on interventional radiology. While teams in diagnostic radiology might pursue similar topics, it will be necessary to expand this list when revising the curriculum for 2013-14 and beyond.	

Table 2.2 RILTC Schedule		
Session	Topic	Homework
Getting Started		
1	Course structure, expectations and model for improvement	Read: The Improvement Guide Create: Project Charter
2	Systems thinking, driver diagrams and choosing improvement projects	
3	Creating teams, psychology of change, change concepts	
4-6	Project charter presentations	
Understanding Variation		
7	PDSA cycles, collecting data, testing predictions	Read: The Improvement Guide Create: Report describing a PDSA cycle
8	Measurement and understanding the two causes of variation	
9	Ladder of inferences, visual display of data (graphs), validity	
10-12	PDSA presentations	
Data Analysis using Tools from Statistical Process Control		
13	Creating control charts with Minitab	Read: Minitab Guide Create: Leadership reports and RSNA Quality Storyboard abstracts
14	Quality as a business strategy, engaging leaders and frontline teams	
15	Calculating system capability from a stable process	
16-18	Leadership reports	
Continuous Improvement		
19	Failure as an informative event, Failure Mode and Effects Analysis (FMEA)	Read: Selected articles Create: Final reports in format suitable for submission to Radiographics
20	Designed experiments and linking improvement cycles	
21	Sustaining the gains and objectively assessing team performance	
22-24	Final reports	

The RILTC will consist of 24 face-to-face 30 min sessions. Twelve sessions will be devoted to topic presentations and twelve sessions will be used for trainee presentations. For the 2012-13 academic year, the PI will prepare and deliver the 12 topic presentations. All 24 sessions will be recorded and available online. This will allow future instructors to build from a common starting point. It will also allow participants to review the content and share their presentations with their teams.

A.2.1.2. Enroll trainees

During the 2012-13 academic year, the course plans to enroll 6 physicians (5 IR fellows and 1 IR Assistant Professor), 2 IR nurses and 2 IR technologists. The reason for this mix is that we want to balance our need to build a self-sustaining internal training program against the desire to disseminate these ideas to the broader radiology community. Since half the trainees will be IR staff, they are expected to remain at our institution for an extended period. They will provide institutional memory, lead future process improvement projects and teach these concepts to their colleagues. The IR fellows will most likely leave the Washington University Medical Center in July 2013 and use the lessons learned from the process improvement training to develop successful projects within their future academic and community practices.

The reason for enrolling nurses and technologists in the RILTC is that effective improvement projects are built around the entire team. Nurses and technologists are key parts of the IR service and including them will leverage their valuable insights and experience. Including them also promotes a collaborative environment within our hospital system and will build bridges to hospital administrators and others who oversee key pieces of infrastructure such as information systems and radiology equipment.

A.2.1.3. Collect/create content and present it to trainees

The RILTC materials will parallel those found in the IHI IA Program and are summarized below.

Table 2.3 RILTC Course Materials	
Item	Comment
Textbooks and reading list	The Improvement Guide[6] is used in the IHI IA Program. Quality and Safety in Radiology[21] is a new text that includes many topics that will also overlap with an optional reading list.[12, 15, 17, 19, 22-33]
Online forms and recorded sessions	Online forms will include: Project Charter, PDSA Report, Leadership Report, Final Report in modified SQUIRE[34, 35] format. Sessions will be recorded to promote learning and future dissemination.
Minitab software with online demonstations	Data-driven projects will require that trainees use tools from statistical process control[36-38]. In contrast to the IHI IA Program which allows a variety of different software packages, the RILTC will focus on Minitab 16 since this software is already used within our organization.

Since learning to efficiently and effectively use Minitab and other new tools will be a key element of the RILTC, the course will include a Minitab textbook[39] and exercises that demonstrate Minitab's features. Figures

1 and 2 were created with Minitab using data from a large CT dataset. Participants will be given this data in an Excel spreadsheet and asked to recreate the graphs. To help participants create such graphs we have been creating step by step tutorials that lead trainees through the process. Some of these tutorials can be found at https://sites.google.com/site/improvingfluoroscopyprocedures/home/training/minitab-training.

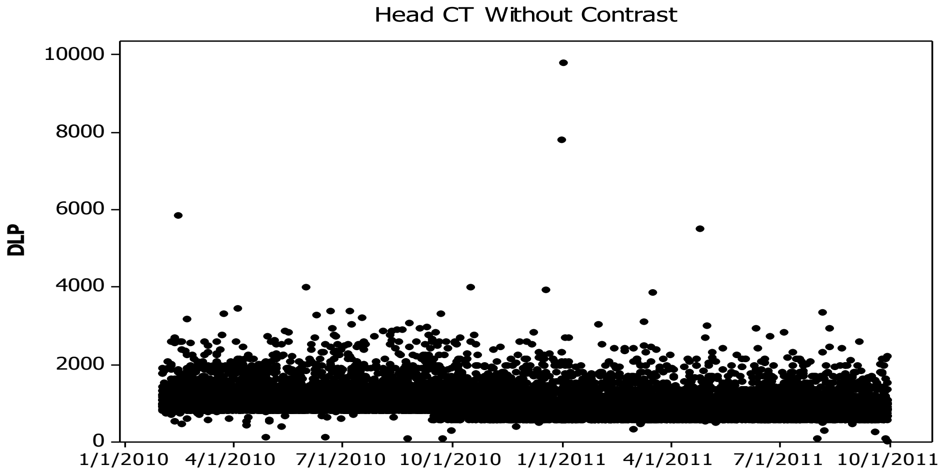

Figure 1: Scatterplot of Head CT exposure versus study date. Since March 2010, technologists have been routinely entering DLP into the Radiology Information System (Siemens Syngo) after each CT exam. This data was extracted from the RIS and filtered using exam codes to identify head CT exams without contrast. Data was manipulated in Excel prior to being copied into Minitab 16.

While scatterplots are useful tools for initial data analysis, they usually fail to convey both the extent and temporal nature of the change. That information is much better communicated via control charts such as Figure 2. Trainees will be expected to create control charts and a variety of other exercises between the classroom sessions and submit their results for review. For these two examples, trainees will be able to compare their results to these figures and minimize any differences. Additional online exercises will require participants to analyze the data and answer multiple choice/fill in the blank questions. These online assessments will be part of determining whether they have mastered the concepts needed to use statistical process control tools in their projects. While such online training is scalable and allows off hours training without an instructor, it does require careful sequencing and segmenting of content.[40-44]

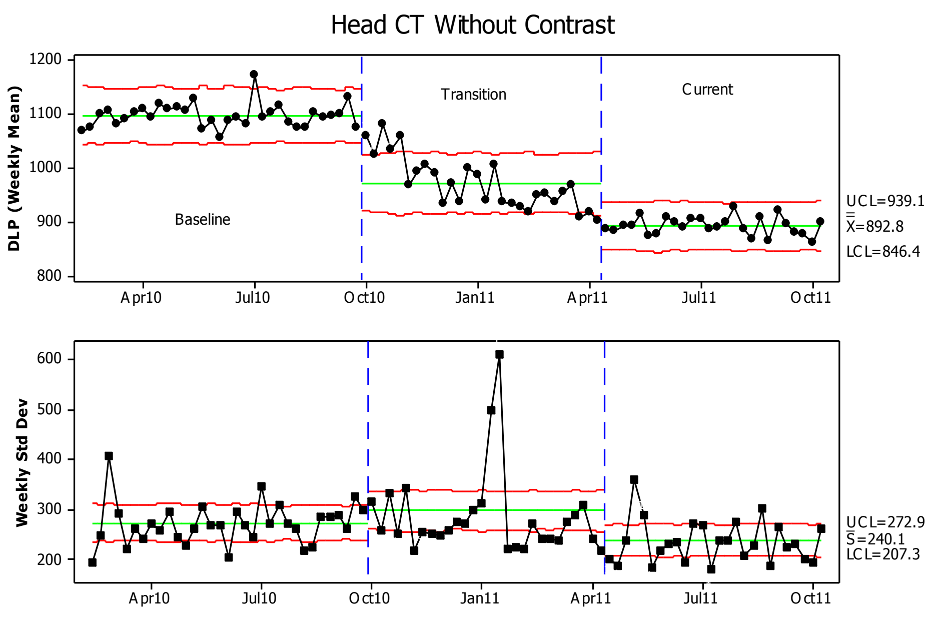

Figure 2: XBar-S Control Chart. Average DLP and standard deviation were calculated and plotted. Upper and lower control limits were calculated and displayed for each week (UCL, LCL, red lines). Average DLP and standard deviation for calculated for each of three phases (X double bar, S single bar, green lines). The first phase (March 2010-Sept 2010) reflects performance of the baseline system. The change phase started in Sept 2010 and retrospective analysis of the data suggested it was complete by May 2011. The third phase (May 2011-Nov2011) reflects performance of the new system.

A.2.1.4. Assess the curriculum's effectiveness

Multiple methods will be used to assess the curriculum's effectiveness. First, the trainee work products including their project charter, PDSA cycles, leadership reports, online exercises and final reports will be reviewed. Trainees will also assess their own progress by completing a pre- and post-course skill surveys using the MUSIQ instrument.[45] Trainees will also prepare quarterly evaluations of their team's progress using the criteria developed by the IHI. We will encourage trainees to submit their work for presentation at the 2012

RSNA Annual Meeting as quality storyboards. This will provide an opportunity for external assessment. While these data will allow us to assess the short term effectiveness of the training program, a key question is whether the RILTC promotes measurable improvement in patient care. Although such assessment extends beyond the time horizon of the funding period (Table 2.4), the topic is addressed in section A3.2 below.

Table 2.4 Task Timeline	**Months Since Project Award**											
2012-2013 RILTC	-4	-2	0	2	4	6	8	10	12	24	36	48
Finalize curriculum and prepare course materials												
Run the course												
RSNA Quality Storyboard Abstract; Final Reports												
2013-2014 RILT												
Revise curriculum												
Run the course												
2014 and beyond RILTC												
Revise curriculum and run the course												

A.3 Deliverables and Future Expansion:

A.3.1. Deliverables from the RSNA perspective

1. Detailed curriculum for a radiology focused course on process improvement
2. Content – much of which will be available online
3. Shared knowledge including RSNA storyboards, publications, and expansion of online content

The project will provide three types of deliverables. The first will be a detailed curriculum that goes well the course schedule shown in Table 2.2. Curricula are plans for learning[46, 47] and resemble the project charters used to plan process improvement projects. The current state, future state and gaps are described. Activities which will bridge those gaps are proposed and their effectiveness is repeatedly measured. Successful training is more than preparing and delivering content, it requires assessing whether trainees gain the desired knowledge, skills and abilities.[48] Persistent gaps prompt a new cycle with a revised curriculum, new/improved educational activities and evaluating the results. The second deliverable will be educational content that includes recorded presentations and online exercises. While our experience with online training for central venous catheter placement demonstrated the large upfront costs of developing online training exercises, there has been a substantial return on investment since the online content has allowed us to expand enrollment and add new training activities without increasing the number of instructors. The third deliverable will be shared knowledge which will be communicated to the radiology audience via the RSNA's educational venues. This includes quality storyboards at the annual meeting, quality improvement publications in Radiographics and project templates posted on the RSNA website.

A.3.2. Future expansion and long term outcomes

One long term goal is a steadily increasing number of physicians, nurses and technologists who understand the scientific basis of process improvement and can apply these techniques to projects in radiology. Since expansion will require training more instructors and enrolling more participants, the RILTC must expand beyond a single institution. The RITLC curriculum and online materials will be designed to facilitate such expansion. In the future, other training courses will be needed since medical students, residents, private practice physicians and senior staff will likely find it difficult to complete the yearlong RILTC. Finally venues for continuing the education of instructors and monitoring their effectiveness will be needed.

Although success with the RILTC coursework and number of RILTC graduates will be key measures, the project's ultimate term goal is to steadily improve the quality and safety of patient care in radiology. Measuring progress will therefore require developing standardized measures that are routinely captured and reported at the national level.[49] Radiation exposure is becoming such a metric but others are needed. Although the long delays between introducing improving our systems and seeing the results at the national level will undoubtedly complicate efforts to improve any other training program,[50] we disagree with those who suggest waiting until measurement systems improve and national metrics are established. We also disagree with suggestions that the improvement strategies used in manufacturing and other industries may not be applicable to radiology. We must begin and the prior work from other fields provides a clear starting point. Once started, we can monitor our progress and use that data to become the best at getting better.[51]

A.4 Literature Cited:

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