

**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: Web-based Protocol and Radiation Optimization for CT with InteraCTive Education (PRACTICE) Program)

Abstract:

Technologic advances in CT have also increased the complexity of scanners and surplus of scanning parameters. Prior studies and national dose estimates have shown 4-8 fold variations in the scan protocols and radiation doses. This wide range of doses in the same scanned body region and clinical indications hint towards variety of scanners, scan protocols, and gaps in knowledge between scanning parameters and their effect on image quality. Our proposal will create web based, user-friendly interactive educational modules for protocol based CT radiation dose optimization that will educate the radiology community about the need and ways for clinical indication driven protocol optimization for adjusting radiation dose. These modules will be centered on electronic data sheets, shared across the globe with the users, with each scan parameter linked to multimedia files such as, didactic PowerPoint slides and video files of brief presentations from CT radiation dose on relevant scan parameters and practices (such as patient centering, tube current, tube potential, helical pitch and iterative reconstruction techniques) acquired on multiple vendor CT scanners. Another aim of this proposal would entail users to add their scanning parameters from several sites across the globe (with support of IAEA) on the central data sheet module and compare their doses, image quality, and practices with regional and national dose surveys and identify outliers. Users will have the option of changing their protocols online and have online experience of the effect of such changes in to their protocols. If users decide to change the scan parameters they will be able to use this module to track and document the changes in their protocols, dose and practices on a secured educational module.

Percent of Time Dedicated to this Project:

81% effort from 07/01/2013 to 6/30/2014

Priority Statement:

Over the past five and half years, I have dedicated my time and research efforts for exploring existing concepts of radiation dose in CT. After graduating from my medical school in India, I joined the premier technical institute of Asia, Indian Institute of Technology, Kharagpur, India, to further pursue my knowledge of medicine and physics. After completing my Masters in Biomedical Engineering, I was fortunate enough to join Massachusetts General Hospital in 2007 as a research fellow working exclusively on CT and radiation dose optimization projects. My efforts were solely geared towards research in different aspects of CT radiation dose, scanning parameters, image quality and several available techniques for dose optimization. My research career on CT and radiation dose started under the guidance of Dr Mannudeep K. Kalra at MGH. I worked with him on several projects related to adjusting radiation dose in CT, including noise projection software, automatic exposure control, noise reduction filters, various iterative reconstruction techniques (ASIR, MBIR/Veo, IRIS, SAFIRE, SafeCT, MBI, iDose, IMR, MLIR). We performed several experiments on phantoms, live patients and even post mortem CT examinations in over 175 cadavers to understand the affects of scanning parameters and test dose optimization techniques. These studies have tremendously enhanced our understanding of low dose CT images and affect of scan parameters in specific body regions. After having written 15 original research articles, 9 book chapters, 7 reviews articles and over 70 oral scientific session presentations on CT radiation dose, my interest in this field is growing everyday. In 2010, I was fortunate to work closely and directly with our department chief, member of Institute of Medicine and prolific educator, Dr James H. Thrall. I have learned, and constantly building up my knowledge from the leaders of radiology community in both research and education. I have organized and taken part in several educational activities, including radiation dose symposiums, lectures at national and international platforms, over 12 educational exhibits at scientific meets, including RSNA, ARRS, ESR. I am an associate director in organizing an annual week long radiation dose workshop, with 10 IAEA countries from Europe and Asia. This course made me realize the existing gaps in knowledge of radiation dose related to CT. As a lecturer in Radiology for the Harvard Medical School and a staff at Massachusetts General Hospital, I am also involved with teaching and training of the medical students, interns, residents and fellows. I enjoy all educational responsibilities and always look forward to finding and filling those gaps of knowledge of CT radiation dose. With the help of acquired post mortem dataset at multiple radiation dose levels, I am actively organizing training of radiologists and help them improve their attitude and confidence of low dose CT images.

Patient safety and optimizing CT radiation dose reduction has always been a high priority for MGH. Over the past several years, MGH has conducted several CT radiation dose optimization studies and resultant hundreds of original peer reviewed articles. MGH imaging is divided into several departments, including chest, abdomen, Neurological, breast, cardio-vascular, musculo-skeleton, emergency as well as pediatric imaging. All the divisions have several ongoing efforts to monitor, identify outliers and optimize CT radiation dose. Dr Thrall has founded the Webster Center for Advanced Research and Education in Radiation, with over 17 faculties working towards one goal of optimizing CT radiation dose. With the proposed project, I wish to accomplish to two important tasks. Firstly, to develop a web based interactive educational module for CT radiation dose and protocol optimization. Secondly, the project will address the issue of educating upcoming and established radiologists on effect of low and standard radiation dose on image quality and lesion characteristics. This training program will provide them with the confidence of interpreting low dose CT examinations, which I believe is a crucial precursor to all low dose endeavors. I also envision that these projects will help me achieve my long-term goals of CT radiation dose optimization at global levels and advance my career as an educator and a visionary for developing practical and novel educational activities in CT imaging community, which have true and immediate benefits for our patients.

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

Project Timeframe: 7/1/2013 - 6/30/2014

Amount Requested: \$74,912

Complete Budget Justification

A. Personnel

Salary support	\$61,327
Programmer	\$ 9,965

B. Supplies

CPU for website server (Mac Pro Quad-Core Xeon)	\$ 3,300
2 TB External hard drives (n=4) \$ 80 per item for 4 items	\$ 320

B. Other (none)

TOTAL PROJECT COST: \$74,912

Other Investigators:

Name: James Brink, MD

Role: Professor of Diagnostic Radiology; Chair, Department of Diagnostic Radiology, Yale School of Medicine. As the incoming, Radiologist-in-chief of the MGH Imaging from February 2013, Dr Brink, has offered his support to facilitate study goals, timelines and ensure adequate efforts for the project. Dr Brink being one of the leaders in CT radiation dose optimization and chair of the Imaging Wisely campaign, he has championed calls and efforts for enhancing educational aspects of radiation dose optimization. With his experience and key interest in CT dose optimization, Dr. Brink will be the primary educational and scientific advisor for this project.

Name: Thomas Schultz, PhD

Role: Systems Engineer. Tom has been with the MGH Radiology Informatics for more than a dozen years and has personally overseen and led several dozen key updates to the Radiology Information Systems at MGH. Together with Dr. Keith Dreyer and Dr. Dan Rosenthal, he has led to creation of online radiology order entry decision support, natural language processing, and RENDER radiology image and text search. He is also deeply involved in developing ground breaking educational platforms for the American College of Radiology using the most cutting edge information technology.

Name: Mannudeep K. Kalra, M.D.

Role: Assistant Professor of Radiology, Massachusetts General Hospital, Boston, MA. Dr. Kalra will serve under Dr. Brink as educational and scientific co-advisor for the project. Dr. Kalra is regarded as a researcher, prolific scientific publisher and active educator in the field of CT radiation dose optimization. Support and guidance of Dr. Kalra will help provide scientific insight for developing educational and research components of the project.

Name: Madan Rehani, PhD

Role: Radiation Safety Specialist, International Atomic Energy Agency, Vienna, Austria. Dr. Madan Rehani, will serve as a key person for identification, enrollment and follow up of participating sites around the globe. He will be the vital link

between central educational and peripheral compliance component the project. He has extended his support for participation of the project.

Detailed Education Plan: (See Next Page)

Section III: Education Plan: A. Detailed Education Plan: Introduction:

- **Rationale and Purpose:**

Concern related to radiation dose related risks is one of the major challenges faced by CT [1-6]. On one hand increasing utilization and technical advances is promising for providing valuable diagnostic information and on the other end of the spectrum; this increases the complexity of CT scanners and surplus scanning parameters. Prior studies have shown 4-8 fold variations in the scan protocols and hence resulting in increase radiation doses delivered to patients [7-10]. This wide range of doses in the same body regions and clinical indications hint toward the gaps in knowledge regarding radiation doses and image quality [11-13]. The American College of Radiology (ACR) has also emphasized the lack of coordinated educational effort to improve insight into radiation dose and image quality [14]. We envision to create web based, user-friendly interactive educational module for CT and radiation dose. In addition, this module will serve the purpose of automated CT protocol optimization based on body regions and clinical indications. This platform will impart knowledge to the users by providing them all the educational multimedia, including CT images at several radiation doses, PowerPoint presentations and video lectures. On this platform, the users will learn while they optimize their CT scan protocols, monitoring doses and finally, lowering doses in gradual steps. We have experience in research and clinical implementation of CT scan protocols and have several original research articles and book chapters on CT radiation dose optimization [15-35]. Massachusetts General Hospital (MGH) has several CT scan models from all the three major scan manufacturers (GE, Siemens and Philips Healthcare). We also have prior educational experience in conducting International Atomic Energy Association (IAEA) sponsored CT radiation dose optimization workshops for several developing nations. We strongly believe that we possess the experience and skills to carry out this educational exercise.

- **Objectives:**

The purpose of our project is to develop a novel, self-driven, web-based Protocol and Radiation optimization for CT with InterACTIVE Education (PRACTICE) program.

Aim 1: Educational content creation and development of a novel web-based module for PRACTICE.

Aim 1.1: Create and assemble multimedia content for CT protocol optimization including protocol templates, didactic nuggets, educational video library, scientific publications, and image gallery.

Aim 1.2: Develop a web-based PRACTICE interface for enabling user-driven interactive education in CT protocol creation and radiation dose optimization.

Aim 2: Implementation and validation of PRACTICE to enable best practices in CT radiation dose in imaging centers from privileged and under-privileged nations in five continents.

Aim 2.1: Self driven education with creation and comparison of baseline CT protocols and radiation doses.

Aim 2.2: Decision making approach in order to maintain or change to CT protocols for best practices in radiation dose optimization.

- **Reasons the project should be undertaken:**

Inspiration and reasons for this project comes from our personal teaching experience with radiologists and technologists from developing and developed nations. Three recent experiences touched my heart and motivated me to initiate this project. Recently, I was helping a visiting radiologist from a major national hospital in Africa with CT protocol for their 16-slice multidetector-row CT. Dr. Am (name changed) expressed surprise that we ask patients to raise their arms above the head for body CT. When I explained to her that arms can not only cause artifacts but also increase the required dose by up to 30%, she commented, "We do all of our chest and abdomen CT with arms by the side of the body. No body ever told us to raise the arms. We rarely receive good training in protocol set up." Then, I came across a technologist who expressed frustration that her radiologists make them acquire delayed images after every abdomen CT to see a contrast filled bladder regardless of clinical indication! Another example, at a very focused meet of Pediatric Radiologists in the United States, a radiologist asked a question to the presenter and ended up stating that his center was scanning kids at 140kV. He was surprised that the audience was surprised as he was not aware that kids are no longer being scanned at 140 kV in any of the other audience's centers.

On a personal level, I believe that this project will help a) Incorporate protocol building routines for CT, b) learn about key scanning parameters that help make good CT protocols, c) evaluate current doses and practices compared to the rest, d) support dose optimization or reduction through educated decision making about its implications, e) help avoid inadvertent miscues or misuse of scan parameters resulting in higher than need doses.

• **Student Population:**

I expect all imaging personnel with interest in CT radiation dose to be the primary learner group of this project including radiologists (dose optimization based on clinical indications, body regions, and image quality), technologists (scan parameters and protocol making), residents (all educational aspects), as well as medical physicists (scan parameters, image quality, various scanner models). This module will help users to understand the effects of scan parameters on dose and image quality and enhance diagnostic confidence.

• **Previous Experience:**

Over the past 5 years, I have gained extensive experience in CT radiation dose research and education. I have assessed and published several dose reduction strategies and techniques including weight based dose reduction and automatic exposure control techniques, investigated 2D image post processing filters, noise projection software, statistical and model based iterative reconstruction techniques from all major vendors (Veo, ASIR, Safire, iDose, IMR, MLIR, SafeCT, MBAI). In addition, I have received several awards such as RSNA trainee research prize, twice (2009, 2012), Magna Cum Laude and Certificate of Merit for CT radiation dose optimization. I also have relevant educational experience, including Refresher Courses on CT radiation dose optimization as a faculty at the Radiological Society of North America’s (RC-124 2011, RC-124 2012), MGH-Harvard Medical School’s grand rounds, and Annual International symposium on Radiation safety in CT, South East Chapter of AAPM (2012), and other invited talks from hospitals around North America. In addition, I have served as an associate director of the annual education workshop of CT radiation dose optimization for IAEA affiliated developing nations.

• **Project Plans:**

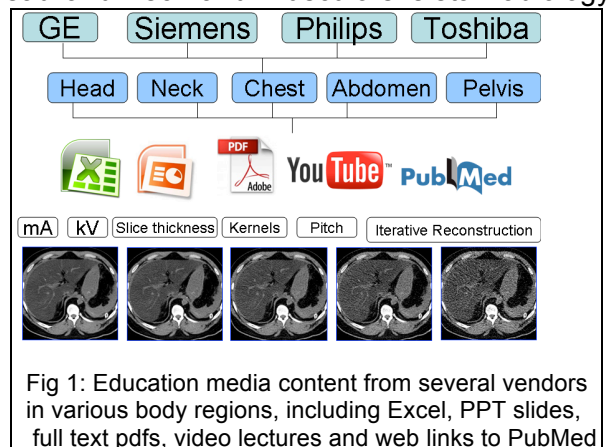
Aim 1: Educational media content creation and development of a novel web-based module for PRACTICE.

Aim 1.1: Create and assemble multimedia content for CT protocol optimization.

Protocol Archive: To start with, we have assembled and organized all CT protocols currently being used at MGH on several CT scanner models (n=18) spanning (6, 8, 16, 64, 128, 256 slices) from major scan manufacturers (GE, Philips & Siemens) in Microsoft Excel. These protocols have been further stratified and optimized by body regions, weights and clinical indications. I have extensive experience with several techniques of dose optimization, including noise reduction filters, noise simulation software, iterative reconstruction techniques (ASIR & Veo; GE, Safire; Siemens, iDose & IMR; Philips, SafeCT; MedicVision, Israel and MBAI; internal MGH algorithm) resulting in several original research and peer reviewed publications. In addition, we will approach Toshiba for their CT protocols and sample images and contact its luminary site for experience with various scanner models. Then, we will pool in recently recommended vendor specific CT protocols from all vendors from the American Association of Physicists in Medicine (AAPM accessed at <https://aapm.org/pubs/CTProtocols/>).

Video repository: We will create several didactic lectures on various aspects of CT image quality and radiation dose in various sub specialties, including thoracic, abdominal, head and neck and musculo-skeletal radiology (Figure 1). These materials will explain scan parameters definitions, their effects on image quality and relationship with dose. These materials will provide several examples of dose optimization with images. We will acquire and organize all the talks from several faculties from MGH and beyond in PowerPoint (ppt) format or portable document format (pdf) readable with freely available Adobe Reader. These video lectures will deliver targeted messages in less than 5-10 minutes clips and will be structured based on successful video series made by the Massachusetts Institute of Technology (MITopencourseware), which provides simplified, short and interesting explanation to complex subjects (36).

Peer-reviewed content: Extensive list of scientific publications and abstracts based on scan parameters will be assembled. Full text “free of cost” pdf of research articles would be web linked. For paid articles, we will contact the journals for either full text or extended abstracts to be shared with users for “not-for-profit” educational purposes. Specific MeSH term based search queries will be created to automatically extract and populate our program on new literature on radiation dose from the MEDLINE.



Dose reduction image archive: In addition, we have an extensive library of CT images acquired at various possible dose combinations of tube current (300 to 13 mAs), tube potential (80, 100, 120 & 140 kVp), helical pitch (0.5, 0.6, 0.9, 1.2, 2.0, 3.1), off centering of CT table (2 & 4 cm up and down iso-center), combinations of localizers (AP, PA, Lat, AP-lat, AP-PA, PA-Lat, PA-AP, Lat-AP, Lat-PA), as well as archived raw data for reconstruction of images at any desired slice thickness or increment (0.75/0.6 mm* 0.75/0.6mm, 2.5mm/3mm* 2.5mm/3mm or 5*5mm, depending on the scanner), and kernels. These data are acquired of scanners from different vendors with various CT optimization techniques, such as, iterative reconstruction algorithms (in house clinical reconstruction techniques on scanners: Veo, ASIR, Safire, iDose, in house research reconstruction box offline from scanners: Safire, iDose, IMR, MLIR, SafeCT and MBAI).

Aim 1.2: Develop a web-based PRACTICE for enabling user-driven interactive education in CT:

Under this sub-aim, we will create a web-based, open access, user friendly website, which after initial validation will be able to run most of the components in an automated user driven manner with minimal maintenance in the long term. MGH owns and maintains CT radiation dose reduction website namely, www.imagingsafely.com, which will be the initial home for this online educational program (Figure 2). We will be obtaining help from an experienced computer programmer with more than 10 years of experience in radiology informatics and creation of educational content for our department and the American College of Radiology (ACR). He will help us to create and additional tab with “live” data entry forms. I also have some experience in computer programming in C++ and MATLAB.

Initially, the website will be accessible to invited personnel only. To access the module, each site will have to respond to an email invite and register with password protection. Users will have the ability to either import CT protocol in excel sheet or will be able to enter the scan parameters individually in each cell. Scan parameters nomenclature will be first displayed as vendor specific terms (to simplify things for the users) with their individual definitions and description of their generic names as per standard nomenclature developed by the AAPM, CT terminology Lexicon (37). The users will be

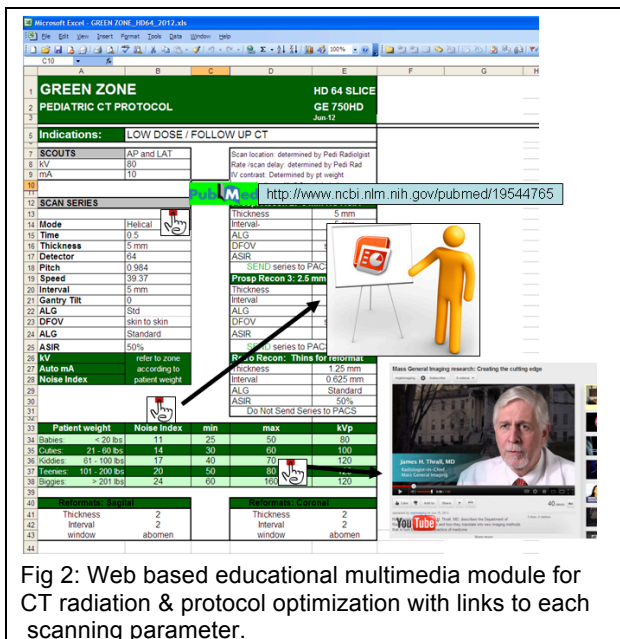


Fig 2: Web based educational multimedia module for CT radiation & protocol optimization with links to each scanning parameter.

able to archive their protocols on the secured access website as well as export their protocols in excel sheet, pdf or Word documents electronic copies. This essential exercise will help self-educate users about need for having well organized CT protocols to avoid guesswork. In addition to the protocols, we will allow the users to upload sample de-identified DICOM images for their protocols, which can then be used to display side by side effect of change in their image quality with modifications in their protocol. Free DICOM de-identifiers will be provided to every user through the web-based module and adequate training will be provided to ensure that this part is not too onerous for the users.

Second part of this aim will be focused to create a simple graphic user interface for images at various doses. Output of this interface would be to “generate” or extract specific image stacks based on the user selected scan parameter, such as tube current or potential. We will add features to display the whole stack of images rather than just a single axial image (Figure 3). Our extensive image database described in Aim1.1 has images acquired with different scan parameters such as various mAs (300 to 13mAs), and kV (80, 100, 120 & 140), and reconstructed at different section thicknesses using different reconstruction kernels and techniques. We will then process the archived and arranged CT raw to reconstruct

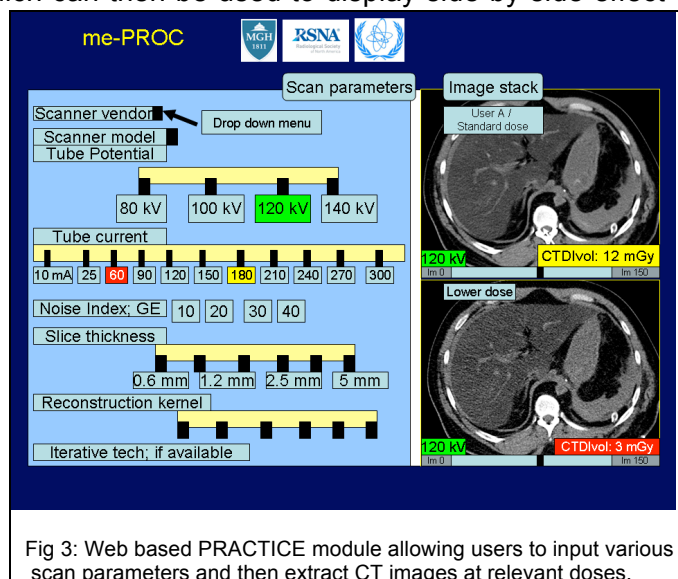


Fig 3: Web based PRACTICE module allowing users to input various scan parameters and then extract CT images at relevant doses.

images with desired parameters. Moreover, as use of iterative reconstruction (IR) becomes more common at several radiology departments, users will be able to see and learn about the visual (with processed images) and theoretical effects (from associated additional presentations and peer reviewed papers) of CT images reconstructed with different IR techniques.

Aim 2. Implementation of PRACTICE in imaging centers to enable best practices in CT radiation dose.

Aim 2.1: Self driven education with creation and comparison of baseline CT protocols and doses.

Several of our past participants from our collaborative MGH-IAEA workshops with representation from 12 countries in Europe and Asia (Israel, Serbia, Republic of Latvia, Bulgaria, Bosnia and Herzegovina, Republic of Croatia, Slovenia, Republic of Macedonia, Sri Lanka, Pakistan and Thailand) have shown eagerness to participate. We are in continuous correspondence via emails or phone calls with each of these attendees. In addition, we will seek support from Dr Madan Rehani to contact other IAEA affiliated nations for this initial phase. Other than these nations, we will identify and include at least 8 sites across North & South America, Canada and India. We will establish a point of contact personnel from each registered site, who will be responsible for uploading scan protocol information and de-identified CT images. All protocols will be then be organized and cross checked from individual user sites. Each protocol will include tabulated information about scanner vendor, type and model number, tube current, tube potential, mode of acquisition (helical vs axial), beam pitch, gantry rotation time, reconstruction kernels, section thickness and section interval, scan localizers, tube current modulation, noise index, typical CT dose metrics such as CT dose index volume (CTDI vol) and dose length product (DLP), to name a few. The program will also look for any missing scan parameters information required for optimizing doses. In rare case, when users cannot be certain about any technical details, such as scanner model number or reconstruction kernels, scanner manufacturers will be contacted directly by the users or our team, as MGH has active research collaboration with all the three major vendors (GE Healthcare, Siemens Healthcare and Philips Healthcare). These scan parameters information would be recorded separately for selected protocol for head and neck, chest and abdominal CT. We will compare doses of the sites with published regional or national guidelines, depending on the location of the site (ACR guidelines, European guidelines (EUR16262), published British surveys, AAPM dose check guidelines, and other national guidelines and publications) (37-45). To introduce the users to the concept of estimated effective doses (mSv), the program will also estimate effective doses from the recorded dose length products. In addition, this step will allow users to compare their doses since some publications and guidelines are available in effective doses and not for CT dose metrics such as CTDI vol or DLP. This step will help users to understand meaning and implications of knowing these dose metrics while they see comparison of their baseline doses versus other centers (such as MGH), guidelines, or publications. When user protocols exceed the recommended reference dose values or guidelines or the AAPM Dose Check values (as a safety measure this document recommends maximum values for CTDI vol for different CT protocols), users will get an Alert message and color and will be prompted to re-check the entered value with CTDI vol or DLP from five additional exams. Initially, we will handpick “outliers” with excessive doses and applied scan parameters causing excess radiation doses for individual site, for each body regions and scanner type. Based on our experience of troubleshooting outliers, we have found that few “faulty” parameters are easy to be detected. For example, use of 140 kV for pediatric scanning, as this should not be used in any possible clinical indications in pediatric settings. We will ultimately within the scope of this project, make the program “smart-enough” to automatically detect and highlight scan parameters in need of adjustment. Once, the users have finished entering their protocols, they will get an automatically generated scores and messages on the same web-page, depending on comparison of their dose to recommendations and use of specific scan parameters. Also, if they move their mouse over an entered scan parameter, they will see the definition of those parameters, typical guidelines on appropriate parameter value and implications of change in those parameters on dose and image quality. This optimization would take place in sync with the individual site participant with simultaneous viewing of the shared excel sheet containing the scan protocol.

Aim 2.2: Decision making approach for best practices in radiation dose optimization:

After conveying baseline average doses, educating users with national/regional reference levels and identifying outlying doses and “culprit” scan parameters, education in protocol and dose optimization will be targeted to user’s specific needs. This training session would target to educate on image quality at optimal doses. We will use the PRACTICE program, created in Aim 1.2, to compare CT images side by side. This template would include visibility of lesions as well as normal tiny anatomical structures. For example, appearance of diaphragmatic crura, adrenal glands, tiny lymph nodes, blood vessels in peripheral 2 cm of the lungs,

mediastinal lymph nodes and other structures are affected by image noise at low doses. Self-driven ppt slides created and organized in Aim1.1 would be then used to show several successful clinical examples in different body regions. In addition to the visual aids of CT images, users will also be provided with online video lectures on “how to” optimize radiation dose. Once the participating site feels confident of lowering the radiation dose without affecting the diagnostic information, this module will then ask the participating site for willingness to adjust dose voluntarily. There response would be recorded and further steps would be taken accordingly. We will then suggest “slightly” lower doses than the current practice. For example, Site A performs “routine” abdominal CT at 120 kV and 250 mA on Siemens scanner with CTDIvol of 30 mGy. We would then select published literature and archive of images with the “PRACTICE” to show them abdominal CT performed at lower dose of 25 mGy. This will allow user’s to visualize and compare image quality at lowered dose and increase the diagnostic confidence. Depending on the scan volumes at participating sites, we would set up reasonable time frames for reevaluation of CT doses. We anticipate 4-6 weeks as sufficient time for accumulation of adequate cases in individual body regions. During this phase, participating site will monitor the doses for the specific optimized CT protocol. CTDIvol, DLP and selected phantom sizes would be recorded for all scans performed during this time frame. At the end of this period, individual sites would once again upload their new “updated” CT protocol and doses. Newer “recommended” doses will be compared to older “standard” doses and once again to national and international representative dose guidelines. Any changes seen in CTDIvol, DLP and effective doses will be recorded and tabulated

After this phase of documentation, module will present a survey to the participating site for their “satisfaction” and confidence as well as willingness to go further for lowering radiation dose. Survey will generate questionnaire for satisfaction with image quality as either “satisfied” or “unsatisfied”. Second question would judge their willingness to take another step toward lowered dose. This would generate a 5 point score, as detailed in Table 2. In addition, quiz presented in Aim 2.1 to test the basics of CT radiation will be presented again after the exercise of education and implementation. In addition, we will contact other radiation dose campaigns, such as imaging safely, imaging wisely as well as other social media, such as facebook, to reach out as many users in the CT community to convey the radiation dose optimization message and education.

Score	Image quality	Willingness to go further
1	satisfied	Let’s go to next step
2	satisfied	Need more time and cases to decide
3	satisfied	Not willing to go to lower dose
4	unsatisfied	Willing to train again and re assess
5	unsatisfied	Want to go back to higher doses

• **Time Schedule:**

	July-Sept	Oct-Dec	Jan-Mar	April-July
Aim1.1: Create PowerPoint’s, excel sheets, record videos and organize image library	█			
Aim1.2: Develop web based PRACTICE GUI		█		
Aim 2.1: Upload protocols, create baseline, educate			█	
Aim 2.2: Decision making approach and iterate, if needed				█

• **Outcomes:** Two main educational projects will be developed through this project. First, we will develop a web based interactive module with web links to educational media readily available on the CT protocol sheet itself. Second module will allow users to visualize and learn about the affect of radiation dose and scan parameters on CT image quality, using archived CT images and raw data. To our best knowledge, this kind of module does not exist in CT radiation dose optimization domain and will help in education of radiologists, technologists, residents and physicists as well as implementation of low dose protocol in clinical workflow.

• **Evaluation:** Outcomes for this education project will be assessed in three ways, first by pre education versus post education and implementation quiz of users. Secondly, we will document objective image noise, as well as subjective radiologist confidence both pre and post education with low dose images. Finally, objective baseline doses (in terms of CTDIvol and DLP), outliers for various body regions, for both pre and post education and gradual steps of lowered doses and or number of outliers, as well as compliance with these low dose protocols will be tabulated for each individual site.

References:

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