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: Technology Assessment for Radiology Residents – A Curriculum to Understand the Economics of Imaging and How to Value a Diagnostic Test

Abstract:

A central theme of healthcare reform is that healthcare interventions must demonstrate an improvement in patient outcomes. Technology assessment is the process by which interventions, be they treatment or diagnostic strategies, are formally evaluated, from the payers' or societal perspective. Technology assessment is principally a synthesis of statistics and economics and, in the case of diagnostic imaging, factors heavily Bayesian theory, decision science and behavioral economics. Technology Assessment is an area of void in the formal education of radiology resident. Even research in this area is relatively scant in radiology compared to other medical disciplines. The academic leadership is cognizant about the importance of this science.

The RSNA devotes entire sessions. The AUR, in partnership with General Electric awards an academic fellowship to cultivate research in this area. Despite these efforts, the understanding of the principles of technology assessment is far from protean amongst academic radiologists, let alone radiology residents.

The aim of the educational curriculum is to fill the knowledge void. The urgency of this undertaking is underscored by the intense spotlight on imaging, which is continually asked to prove its value or face relegation. The broad scholarship will be distilled through a series of video-recorded lectures and supported by a website on which reading material and discussion board and will be posted. Emphasis will be on problem solving. The long term goal is to emulate the ACR case-in-point in terms of the regularity of fresh cases and the germination of a pool of contributors. It is anticipated that the curriculum will inspire the young mind of a trainee to imagine further research in economics as applied to diagnostic imaging or, at the very least, be fluent in the lexicon in order that they appraise such studies.

Percent of Time Dedicated to this Project:

Project: 30 %
Administration and Teaching: 10 %
Clinical work: 60 %

Priority Statement:

I have been an Assistant Professor for four years. My clinical interests include cardiovascular imaging and emergency radiology. My scholarly interests include the economics of diagnostic imaging and policy research pertaining to imaging. The departmental support for my position on the clinical educator track was with the view of the development of an academic program in health services research in general and technology assessment in particular. To that end the department has supported my pursuit of a Master's degree in Health Policy from the Leonard Davis Institute (LDI) of the University of Pennsylvania, which I am near completion. This has been a unique intellectual opportunity. I am fortunate to have been taught by some of the leaders in the field such as Mark Pauly (health economics), David Asch (policy) and Howard Kunreuther (behavioral economics). The degree permits certain latitude and I have combined courses in topics ranging from clinical trials, Bayesian analysis, cost effectiveness analysis, welfare economics, decision science, risk and behavioral economics. I viewed the course from the prism of a diagnostic imager and now I am able to view imaging from the perspective of many disciplines. This unique insight motivates me to disseminate what I have learnt.

I was awarded the General Radiology Research Academic Fellowship (GERRAF) to develop economic models to determine the most cost-effective diagnostic strategy for the evaluation of a patient with suspected coronary artery disease. In addition to providing a substrate for the theory I was learning, I was mentored by titans in this field such as Sandy Schwartz, Alvin Mushlin and Ronald Arenson. In the master's program I was the sole radiologist. I was amazed during the group discussions how effective, important and otherwise deficient the perspective of a radiologist can be. Equally, I was filled with trepidation at the thought of how unaware our profession might be of the lexicon that it used to advance the case for its vitality. As the spotlight on imaging shines with ever greater ferocity, I feel that there is still a case to be made that appropriate imaging is under-valued, even if imaging in the aggregate may be over-priced. Driven by what I perceived to be dangerous crevasses in our knowledge, I developed a curriculum in economics for the radiology residents featuring lectures in probability theory, microeconomics, health care economics and decision science. This was warmly received, particularly by residents with no formal training in mathematics and economics and my qualitative approach, rich in allegories and imaging-specific examples, was praised. I am an avid reader with a broad scholarly interest. I run a highly successful resident book club where non-fiction books of relevance to healthcare are discussed. I believe that an inquisitive mind that can analyze the regulatory milieu must be fed a diet of extensive reading beyond the immediate academic texts in radiology. I also moderate a

health policy resident journal club, where papers in high impact journals with a potential policy-changing angle, are subjected to a Socratic-style discussion.

I have constantly scored one of the highest in the evaluations by residents for my teaching and mentorship. I believe this is largely because I am able to convey concepts in simple terms. I was awarded for excellence in teaching as a radiology fellow principally for my exposition of physics of magnetic resonance and computed tomography. I have lectured on the principles of cost-effectiveness analysis at our grand rounds and national meetings such as the North American Society of Cardiac Imaging (NASCI) and the American Heart Association. I serve on the Technology Assessment working group of the Society of Medical Decision Making, ACRIN Outcomes and Economics Committee, ACR Committee on Accountable Care Organizations and RSNA Health Policy Sub-committee. As a member of the NASCI educational committee I made significant contributions to the cardiovascular imaging curriculum. At my behest, an entire section has been devoted to the economics of cardiac imaging. I am currently the site principal investigator for a large randomized controlled trial (RCT) comparing cardiac CT to SPECT for angina. This has given me insight in to the unique challenges of conducting RCTs in diagnostic imaging. I serve on the ACR e-learning sub-committee. I anticipate that in this position I will receive valuable live critique and advice on the most optimal method of dissemination of the educational contents to the maximum number of residents. I sometimes ask whether I see myself as an educator or researcher. I have concluded that this is a false dichotomy. I cannot fathom how one can be enthused about their research without the accompanying desideratum of sharing the principles with a larger audience.

My motivation for creating a curriculum and a learning base for technology assessment and the economics of diagnostic imaging is only partly explained by the zest that has arisen from what I have learnt. More importantly, I feel a sense of urgency that this subject matter be conveyed with clarity and excitement to an audience in whom the lies the reigns of the future of imaging, namely our trainees. I do not feel that most radiology residents need to know the principles of technology assessment to the level of an advanced degree, although I will make no secret that I would be delighted if many more followed my interests. However, I do believe that level of understanding of this subject be such that the resident when graduating to a position of greater responsibility, with or without formal officiation, be able to ask the right questions. In summary, I feel that a curriculum in technology assessment/ economics of diagnostic imaging represents an area of need in the education of a radiology resident. Whilst there are undoubtedly many great texts in this subject, a distillation boasting intellectual breadth, simplicity, clarity and relevance to imaging is distinctly conspicuous at present time. I feel that I am well placed to undertake this venture.

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

Project Timeframe: 7/1/2012 - 6/30/2014

Total Budget: $150,000

Complete Budget Justification

Year 1

A. Personnel	
Salary support	$70,000
Website design - ($80 per hour for estimated 50 hours)	$ 4,000
Audiovisual aid for filming lectures	$ 1,000
B. Supplies (None)	
C. Other (none)	
Year 1:	$75,000

Year 2

A. Personnel	
Salary support	$70,000
Website design - ($80 per hour for estimated 50 hours)	$ 4,000
Audiovisual aid for filming lectures	$ 1,000
B. Supplies (None)	
C. Other (none)	
Year 2:	$75,000

Total Project Cost: $150,000

Other Investigators: N/A

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

INTRODUCTION: Rationale and Purpose

A key message in healthcare reform to radiologists is that diagnosis is not enough. Imaging leading to a diagnosis must be shown to improve patient outcomes – i.e. combat the morbidity and mortality (1).

I doubt that anyone would object to this requirement, which is intuitive enough, and which all clinicians should strive for. However, hidden in the simplicity of this truism is the methodology by which diagnostic imaging, indeed all of health technology, is valued. This process is known as Technology Assessment (2). Understanding the methodology requires a basic grasp of several disciplines including statistics, economics and decision science, but mainly economics. Appreciating the limitations requires familiarity with Prospect Theory and the aptly termed Irrational Economics (3).

The goal of the proposal is to create an educational backbone for radiology residents to understand the basic principles of the sciences involved in Technology Assessment, as relevant to imaging, through a series of lectures supported by an online vehicle.

The academic leadership has long recognized the importance of technology assessment in radiology (4). The Association of University Radiologists (AUR) has partnered with General Electric to promote outcomes-based research through an academic fellowship. The RSNA holds special sessions and the Journal of American College of Radiology has an entire edition to its devotion (5). Nonetheless, there is no resident curriculum, lecture series or online resource that is at once readily accessible from a single source, comprehensive and multi-disciplinary.

It is important to emphasize that this proposal is about economics not business. To illustrate the difference, consider the argument for a 3 Tesla MRI from the perspective of an economist and business analyst. The economic analysis must show that incremental diagnostic accuracy of 3 T over 1.5 T not only improves the detection of disease process but also, and as a result of the improvement, alters management leading to improved patient survival. The business analyst, for whom the economic argument may be assumed, would focus on the return of investment from the perspective of the radiology group. Whilst the business analysis is influenced by regulation the economic analyst seeks to influence the regulators by showing the value of the imaging to society at large.

Objectives

1. Creation of a lecture series bringing together disparate disciplines forming the fundamentals of Technology Assessment of Diagnostic Imaging.

2. Establishment of an online resource for lectures, pertinent research, interactive problems and discussion on topics apposite to technology assessment.

3. Creation of a high level of literacy in economics amongst radiology residents to better prepare them for the value-based paradigm post healthcare reform.

Student population

The target audience comprises principally residents in radiology but the curriculum will also be useful to medical students who are interested in imaging or who may be pursuing further study in clinical research, epidemiology or health economics. Practicing radiologists, particularly those in positions of leadership and administration, will find the material useful.

Previous experience

I am near completion (graduation May 2012) of a Master's degree in Health Policy. In this I have completed graduate level courses in statistics, economics and decision science with a view to strengthening my own foundations in technology assessment. A concurrent GERRAF award and project on economic analysis of diagnostic strategies for coronary artery disease has strengthened my understanding of the basic principles and its application in real time.
I am the director of the "Economics of Diagnostic Imaging" course for radiology residents. This smaller scale version of my educational proposal has been well received by the residents. In addition, I lecture on probability theory and principles of Bayesian analysis for the Introduction to Academic Radiology course. I have also lectured on basic principles of cost effectiveness analysis at NASCI and AHA meetings. I run the health policy journal club and a book club in much the same format as I would like to transfer to the online learning center.

PROJECT PLANS: Activities

The four pillars underpinning the curriculum and its delivery include lectures, online source, interactive problems and feature of the week. The emphasis will be on fundamental knowledge, comprehensive coverage of disparate subjects and constant relevance to diagnostic imaging.

1. Lectures: The subject matter will be taught through a series of filmed lectures. Each lecture will be preceded by a manageable reading list and followed by a test available online. An estimated 40 lectures (appendix 1) will cover the basics of probability theory, statistics, welfare and behavioral economics and decision modeling, the concretion of which represents basics of Technology Assessment. This can be taken leisurely over the course of the residency.

2. Online source: A website will accompany the curriculum. Initially, the website will serve as a repository of lectures and reading material. Later, and crucially, it will function as an online source and first port of call for evidence, economics and policy as relevant to diagnostic imaging.

3. Interactive problem solving: To aid learning questions, both qualitative and quantitative, will be presented in a step wise manner, with multiple options, and an explanation for both the correct and incorrect answer, modeled on the successful ACR case-in-point (CIP). Participants may keep track of their score and evaluate progress.

4. Feature of the week: Weekly presentation of antecedent and current high impact studies pertaining to imaging economics, non-fiction books relevant to health policy or quantitative problems and solutions will be a key feature of the online learning center. The intention is to keep the online site organic and self-perpetuating replete with contributors from radiologists who practice health services research.

Reaching out to residents:

1. E mailing the program directors individually to alert them of this learning opportunity for their residents.
2. Presentation to the ACR resident and fellow section at the annual meeting.
3. Presentation to the American Alliance of the Academic Chief Residents in Radiology and the Association of Program Directors in Radiology, at the annual AUR meeting.
4. Advertisement through the residents' meeting lounge at the annual RSNA meeting.
5. Presentation to the residents' section at the Pennsylvania Radiological Society annual meeting.

Time to schedule

July 2012 – December 2012: Completion of the first 10 lectures and the website. The lectures will be available online on 01/01/2013 for trial viewing and feedback, restricted initially to

residents from Pennsylvania.
January 2012 – June 2012: Completion of lectures 11-30 and accompanying test questions for lectures 1-30. By July 1st 2013 the lectures will be online and available to all residents.
July 2013 – December 2013: Completion of lectures 31-40, their accompanying test questions and starting material for weekly interactive problems. By January 1st 2014, the online forum will start the weekly interactive teaching problem.
January 2014 – June 2014: Creation of a bank of teaching problems to set in motion the interactive and ongoing educational program. By July 1st 2014, recruitment of other health service researchers to make contributions to the online program.

Outcomes

1) A lecture series comprising the integration of statistics, economics and decision science as relevant to diagnostic imaging forming the fundamentals of technology assessment.
2) An online repository of lectures, reading material, problems and solutions.
3) An online center which can serve as a first port of call for education in evidence, economics and policy, as pertains to diagnostic imaging, with an attempt to emulate the ACR CIP in design, number of contributors and popularity.
4) Creation of a basic knowledge base amongst residents teaching them how to value imaging and preparing them for the intellectual environment post healthcare reform.
5) Creation of a vibrant community of trainees and established radiologists exchanging ideas and knowledge pertaining to evidence, economics and policy.

Evaluation

1. Feedback: All visitors to the site will be asked to provide feedback (appendix 2) on the lecture quality, website design and exposition of quantitative and qualitative problems. The curriculum will be available after the first 12 lectures to residency programs in Pennsylvania for critique.
2. Level of participation: The curriculum can be judged by the number of online visitors, registered users and participants in discussion forums and quizzes. In the longer term, the number of contributors will also be a metric of success of the educational vehicle. Since there is no normative frame for the optimal number at any point in time the curriculum would be best judged longitudinally.
3. Test: Residents will have the option of taking a test at the beginning and end of each lecture to determine their knowledge base and understanding (appendix 3). The improved score in the test is of course a metric of their degree of understanding, 80 % a not unreasonable expectation. However, the mere taking of the test is a substrate for interest in the subject matter, and is another useful metric to adjudicate the success of the curriculum.

References

1. Pandharipande PV and Gazelle GS. Comparative effectiveness research: what it means for radiology. Radiology 2009;253(3):600–605.
2. Fryback DG, Thornbury JR. The efficacy of diagnostic imaging. Med Decis Making 1991;11:88–94
3. Kahneman D, Tversky A. “Choices, Values, and Frames”. American Psychologist 1984;39:341-350.
4. Otero HJ, Rybicki FJ, Greenberg D, Neumann PJ. Twenty years of cost-effectiveness analysis in medical imaging: are we improving? Radiology 2008;249:917–925.
5. JACR May 2009; 6 (5): 287 - 386

Appendix 1: List of lectures

1. Diagnosis is not enough. The rationale of technology assessment for imaging.
2. Introduction to probability theory.
3. Bayes’ theorem and its applicability to diagnostic imaging.
4. Why do we test? Test threshold and treatment threshold.
5. Statistics of a diagnostic test – basic (sensitivity, specificity, likelihood ratio, p values).
6. Cost of false positive versus cost of false negative. Is sensitivity more important or specificity?
7. Receiver Operating Characteristics Curve.
8. Statistics of a diagnostic test – advanced (recursive partitioning and logistic regression).
9. Biases in the diagnostic testing literature.
10. Screening tests versus diagnostic test versus prognostic tests.
11. Anatomy of a clinical decision rule. Ottawa Ankle rule
12. Anatomy of a clinical guideline for diagnostic strategy
13. Introduction to microeconomics
14. Overview of health economics
15. The core tenets of welfare economics
16. Uncertainty and the economics of healthcare – a discussion of Kenneth Arrow’s seminal paper.
17. The economics of information. How do we value information in the age of scarcity?
18. Concept of expected value. Standard utilitarian theory.
19. Cost effectiveness analysis – rationale and method
20. Cost effectiveness analysis – accounting the costs
21. Outcomes, end points and clinical trials.
22. Quality associated life years.
23. Rates, probability and life expectancy
24. Decision analysis – building a simple model
25. Decision analysis – building an advanced model
26. Decision analysis – dissecting an established model (model used by US preventative taskforce for recommendations about breast cancer screening)
27. Willingness to pay.
28. Challenge ROC curves. How sensitive and/ or specific does a new test have to be to be more cost effective than the standard of care.
29. Clinical trials versus economic models – the case of screening for lung cancer
30. Strengths and limitations of decision modeling
31. Technology Assessment, comparative effectiveness and cost effectiveness.
32. Overview of behavioral economics – prospect theory
33. Overview of behavioral economics – risk aversion, sub-certainty effect and value of a negative test
34. Economics of diagnostic imaging – how do we measure the intangibles?
35. Hypothetical example: Adjudicating the value of a new diagnostic technology to add or replace an existing paradigm. How do I go about it?
36. Hypothetical example: Planning a clinical trial to assess the value of a new diagnostic technology to add or replace an existing paradigm.

37. Historical example 1: Diagnostic strategies for suspected coronary artery disease
38. Historical example 2: Screening for coronary calcification
39. Historical example 3: MRI for rheumatoid arthritis
40. Historical example 4: Advanced imaging for plaque vulnerability

Appendix 2: Feedback
Assuming a score of 1 for dissatisfied and 5 for very satisfied please rate the curriculum for the following:

a. Clarity of lecture.
b. Choice of topic.
c. User-friendliness of website.
d. Explanation of quantitative problems.
e. Pre-lecture test.
f. Post-lecture test.
How would you improve the lecture quality?
How would you improve the web interface?
What was your degree of understanding of the topic before the lecture? (1 –little understanding, 5 – complete mastery)
What was your degree of understanding of the topic after the lecture? (1 –little understanding, 5 – complete mastery)

Appendix 3: Example of Test question

Pre-test. Bayesian principles

The Simpsons have 2 children. One of them is a daughter. What are the chances she has a sister?

a) 25 %
b) 33 %
c) 50 %
d) 66 %
e) This is too easy for me to answer!

Answer:

a) 25 % - incorrect. That is the likelihood of having 2 same gender siblings.
b) 33 % - correct!
c) 50 % - incorrect. That would be the correct answer if you knew she was the oldest or youngest.
d) 66 % - wrong answer.
e) This is too easy for me to answer! – Really! You might be surprised.

Explanation

The key to understanding Bayesian analysis is that probabilities are **revised in lieu of new information**.

The possibilities are: girl-girl/ girl-boy/ boy-girl/ boy-boy. The chances of a 2 daughter family are 25 %. But we know that one of the siblings is a girl. Thus, we can eliminate boy-boy combination. We are left with girl-girl/ girl-boy/ boy-girl. The mere knowledge that one of the siblings is a girl has raised the 2 daughter chances from 25 % to 33 %. This is the basic essence of conditional probability.

Now you have the knowledge that the girl was the older one, the probability that the sibling is also a girl goes up to 50 %. In essence probabilities have been revised in lieu of new information.

Post-test. Bayesian principles

1) What is the probability that an asymptomatic woman between the ages of 40 and 50 who has a positive mammogram has breast cancer if 7 % of mammograms show cancer when there is none? Incidence of cancer is 0.8 % and the false negative rate is 10 %.

a) 93 %
b) 90 %
c) 10 %
c) 9 %
e) 30 %

Responses

a) 93 % - no this is the specificity
b) 90 % - no this is the sensitivity
c) 10 % - as mentioned this is the false negative rate
d) 9 % - correct! Please see explanation
e) 30 % - incorrect

Explanation

What is being asked for is the probability of breast cancer **given** a positive test (positive predictive value). Note this is very different to probability of positive test **given** breast cancer (sensitivity). As you know from Bayesian principles (link to Bayesian lecture) P (A/B) is not the same as P (B/A).

Positive predictive value is dependent on the prevalence as well as the sensitivity of the test. A common mistake is to confuse sensitivity and positive predictive value. This results in much undue anxiety amongst patients and physicians.

A detailed exposition is described below.

7 % of mammograms show cancer when there is none. This is FP/ FP + TN or (1 –specificity) giving a specificity of 93 %

False negative rate = FN/ FN + TP which is (1-sensitivity) giving a sensitivity of 90 %
Incidence of cancer is 0.8 % or 80 out of 10, 000 women, making 9920 without cancer.
TP – 72, FP – 694 and PPV (probability of cancer given a positive test) is 72/ 72 + 694 = 9.4