Developing Faculty in Emerging Areas of Interdisciplinary Research

David L. Coleman M.D. , Lisa R. Tannock M.D. , Michael Pignone M.D., M.P.H. , Alpesh N. Amin M.D.M.B.A. , Patricia W. Finn M.D.

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Perspectives Viewpoint

- Departments of Medicine have an extraordinary opportunity to develop emerging interdisciplinary research areas that have the potential to transform prevention, diagnosis, and treatment of disease;
- The success of these new research initiatives will depend on successful faculty recruitment, development, mentoring, and promotion;
- We describe examples of departmental investments in core resources, training, organizational structures, and recognition and promotion of faculty designed to facilitate success of faculty in these exciting areas.

Developing Faculty in Emerging Areas of Interdisciplinary Research

David L. Coleman, M.D.[1], Lisa R. Tannock, M.D.[2], Michael Pignone, M.D., M.P.H.[3], Alpesh N. Amin, M.D., M.B.A.[4], Patricia W. Finn, M.D.[5]

[1]John Wade Professor and Chair, Department of Medicine, Boston University School of Medicine and Boston Medical Center, Boston, MA

[2]Professor of Medicine and Chief, Section of Endocrinology and Metabolism, University of Kentucky School of Medicine, Lexington, KY

[3]Professor and Chair, Department of Internal Medicine, Dell Medical School at the University of Texas at Austin, Austin, TX

[4]Professor and Chair, Department of Internal Medicine, University of California, Irvine School of Medicine, Irvine, CA

[5]Earl Bane Professor and Chair, Department of Medicine, Associate Dean, University of Illinois College of Medicine, Strategic Initiatives, Chicago, IL

Corresponding Author: David L. Coleman, M.D., Department of Medicine, Evans 113, 88 East Newton Street, Boston, MA 02118. Phone: 617-638-7254; Email: colemand@bu.edu

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Abstract

The availability of new techniques and technologies to answer important medical questions is accelerating at a breathtaking pace. In response to these exciting new opportunities, clinical departments in general, and departments of medicine, in particular, have broadened their research portfolios. Organization of the traditional structures of clinical departments, research infrastructure, training programs, and rewards for faculty have only begun to catalyze emerging research areas such as artificial intelligence, bioinformatics, bioengineering, cell and tissue engineering, cost effectiveness, health services, implementation science, integrative epidemiology, medical informatics, nanomedicine, and quality improvement. Success in these emerging areas of research requires inter-disciplinary collaboration on a much larger scale than in the past. The effectiveness of efforts to recruit, develop, mentor, and promote faculty in these exciting areas will be critical to the success of departmental and institutional research programs. Therefore, we describe examples of initiatives from our five departments of medicine designed to develop and promote faculty conducting research in emerging interdisciplinary areas. We focus on core resources, training, organizational structures, and recognition and promotion. Faculty have a compelling opportunity and obligation to pursue emerging research areas that have potential to further improve the prevention, diagnosis, and treatment of disease. As departments further prepare to meet this exciting opportunity in the future, the lessons learned must inform investments in faculty development. Although many of the strategies outlined herein could and should expand beyond any individual department, departments of medicine have a distinct obligation and opportunity to lead this effort.

Introduction:

Clinical departments, particularly departments of medicine, have traditionally been organized in organ-based sections or divisions that align training requirements for graduate medical education, clinical practice, and research. The research programs in departments of medicine have been historically predominantly conducted by faculty in laboratory-based research, often related to the clinical specialty. The traditional model has been highly successful-indeed, the development and accomplishments of physician scientists working on fundamental mechanisms of disease has led to critically important improvements in the prevention, diagnosis, and treatment of disease. As new approaches and opportunities for discovery are accelerating and physician scientists are essential for their success, research-intensive clinical departments have critically reviewed the traditional organizational approach to program development and to the needs of their faculty (1-3).

The research opportunities for faculty in departments of medicine have evolved in response to the evolution of science and technology, research methods, and funding priorities. First, the growth of artificial intelligence, bioinformatics, epidemiology, health services, implementation science, medical informatics, and quality improvement has created novel and important opportunities for faculty and trainees. Second, interdisciplinary approaches to medically important research questions have become increasingly powerful and necessary. Third, the wide gap between discovery and successful implementation has created an urgent need to improve the practice of medicine and to combat persistent health disparities and poor outcomes among substantial segments of the American population. Fourth, despite the impact of social determinants of health, successful strategies and partnerships necessary to recognize and mitigate these factors have not been adequately developed (4, 5). Finally, clinical departments and their respective academic health systems have become increasingly focused on jointly providing high value clinical care in a dynamic healthcare marketplace.

To fully respond to these exciting opportunities, faculty in departments of medicine are working across disciplines and departments. Since the effective development of faculty will be the crucial determinant of institutional success, we provide suggestions herein for how departments can facilitate the success of faculty working in new interdisciplinary research areas. Examples of these new research areas are listed in Table I. Based on our experience in five different departments of medicine, we describe what we believe are key elements in helping faculty fully realize the potential of interdisciplinary research: enabling resources, training, organizational structures, and recognition and promotion (Table II). Our goal is to assist clinical departments, especially departments of medicine, in successfully developing faculty in these continuously evolving interdisciplinary areas of research.

Training and Mentoring:

Training Programs: The emergence of research opportunities such as those listed in Table I, has created a need for a more diverse array of training programs for faculty and trainees. For example, training programs in implementation science and health services research, such as those

offered by the VA Quality Scholars Program or the Robert Wood Johnson Clinical Scholars Program (6, 7); and training programs in community partnerships and community-based participatory research have been developed. Institutional Clinical Translational Science Award Programs, schools of medicine, and schools of public health have developed research training in epidemiology, bioinformatics, biostatistics, medical informatics, development of clinical research and Institutional Review protocols, design of new clinical trial methods, regulatory compliance, and quality improvement (8). Institutions can develop these resources locally or in partnership with other local, regional, or national partners, including health systems and payers.

The evolution of many health systems into Learning Health Systems (LHS) requires a growing cadre of faculty skilled in Patient Centered Outcomes Research methods. The LHS core competencies include data integrity and integration of research findings into operations and policy (9). The Agency for Healthcare Research and Quality has developed an ambitious career development program for faculty to accelerate closure of the gap between evidence and clinical practice in LHS (10).

Mentoring Programs: Since mentorship has been shown to improve faculty productivity, retention, job satisfaction, and sense of "fit", proactive and sustained efforts to mentor faculty in emerging areas is critically important (11). The interdisciplinary nature of these areas may require further attention to the mentoring teams and individual development plans. Providing adequate mentoring, especially mentoring across traditional units such as divisions and departments can be challenging. A holistic approach to mentoring programs should include: oversight of the program to insure use of best practices and alignment with institutional priorities; explicit ground rules for participation in the program; training for both mentees and mentors; incentives for mentors; careful matching of mentors and mentees; establishment of joint goals and expectations in the mentoring relationship; clear mentoring processes and outcomes; and incorporation of the program in institutional processes such as awards, promotion, and determinants of programmatic success (11).

Research Cores:

Instrumentation Cores: The success of research instrumentation cores is highly dependent on conducting an assessment of potential needs, suitability of commercial alternatives, a sound business plan, cutting edge technology, staff support and analytics, and a robust training function. Failure to address each of these elements will greatly limit the effectiveness of the cores.

The training capacity of on-site instrumentation cores can influence the successful uptake of new technologies. Many faculty and trainees benefit from symposia that describe the principles of the technology and user-friendly "hands on" examples of potential applications. In addition, research stipends for new core users seeking preliminary data for grant applications can also be very helpful to faculty and cost-effective for the institution. These stipends can also be used for commercially available services, but may be less flexible and convenient in meeting this need.

Biostatistics: Access to biostatistical support for development of valid approaches to research design and analysis is critical for individuals working in all research areas, particularly in complex interdisciplinary research involving human subjects.. While many institutions have biostatistics departments, the faculty in these departments may be obligated to training and research within their department and therefore less available for consultation, especially at the pilot or unsupported stage. Although many CTSAs support services in study design and biostatistics, access may be limited. Additional approaches to ensure adequate access for faculty within departments of medicine can include funds to "buy" time for biostatisticians to work with departmental faculty, cross-appointment of biostatistical faculty to departments of medicine, and non-salary financial support such as co-sponsorship of biostatistics trainees or post-doctoral fellows. While these approaches may require initial resources, the return on investment can be significant.

Bioinformatics: The use of expertise in computer science, machine learning, natural language processing, and artificial intelligence will be increasingly powerful in the analysis of "omic" data. Programs or sections of computational biomedicine have been very effective in meeting the computational needs of faculty in clinical departments and, importantly, in designing new analytical tools needed for personalized approaches to clinical care. Several examples of bringing bioinformatic approaches into department of medicine are noteworthy. The Section of Computational Biomedicine in the Department of Medicine at Boston University School of Medicine (BUSM) was established in 2009 (12, 13). The faculty in the Computational Biomedicine Section have worked intensively with faculty from other disciplines to develop airway diagnostic biomarkers for identifying patients at risk for lung cancer (14), and for potential therapeutic pathways for breast cancer (15) and emphysematous lung disease (16). The Department of Medicine at the University of Illinois at Chicago (UIC) works collaboratively on joint recruitments, doctoral training, and multidisciplinary grant applications in bioinformatics with the Departments of Bioengineering and Biostatistics. The Department of Medicine at UC Irvine hired a bioinformatician to facilitate translational studies and integration of data from the electronic health record and biorepositories into clinical trials.

Biorepositories of patient-derived samples are rapidly expanding in a number of institutions. These biorepositories provide exciting opportunities for a broad array of clinical and laboratory scientists to further characterize associations that can improve the prevention, diagnosis, and treatment of disease. The Department of Veterans Affairs' Million Veteran Program is designed to correlate genotypic information with clinical data in the electronic health record of one million patients (17). These biorepositories will require new bioinformatics resources to make meaningful clinical inferences from the data.

Medical Informatics: Medical informatics typically focuses on the analysis of biomedical data in administrative and clinical databases. These databases have enormous potential for characterizing large populations of patients. Associations identified from analyses of electronic health records can guide the development of prospective trials and reveal associations or effects within different clinical subtypes. Pragmatic clinical trials are also facilitated by the use of electronic health records (18). The eMERGE initiative of NIH represents an important example

of the use of electronic health records and genomic information to evaluate disease associations (19).

Collaborative teams of medical informaticians and clinicians are particularly desirable. For example, a team of clinicians and informaticists at the University of Kentucky are working to analyze electrophysiological data for potential causes of sudden death in epilepsy. Another example is a web-based tool that extracts clinical data from multiple sources to match patients to ongoing cancer clinical trials (19). To further expand the training opportunities for clinical faculty and trainees in medical informatics, a number of institutions, including the Department of Medicine at UIC, have partnered with other departments to create multidisciplinary fellowships in medical informatics.

Another example of the application of medical informatics has been the Translation Technology Enabling High Quality Care Research Program developed in the Department of Medicine at the University of California, Irvine (UCI). A group of investigators with backgrounds in medicine, health policy, technology, hospital medicine, health economics, psychology, and engineering have developed tools to improve clinical outcomes, generate funding, and create interdisciplinary mentorship (21-23).

New Organizational Structures:

Development of new organizational structures to foster interdisciplinary research has become increasingly common. These structures may be focused on a specific disease or clinical problem (e.g., neuroscience centers, diabetes centers) or, alternatively, on developing methodologic innovation (e.g., Robert Wood Johnson Clinical Scholars Program, Epidemiology Research Centers).

Interdisciplinary Research Centers: Interdisciplinary research can be facilitated by supportive infrastructure, sharing core facilities among disease-focused research centers, convening of interdisciplinary symposia, and by providing pilot funding that requires multiple PI submissions by faculty from different disciplines. The Evans Center for Interdisciplinary Research in the Department of Medicine at BUSM was established to facilitate interdisciplinary research. The center provides up to three years of pilot support for a series of affinity research collaboratives (ARCs) formed by faculty with shared research interests across a broad range of disciplines. The center's ARCs have generated 145 extramural grants and over 535 publications (24) since 2009. Key elements in the success of this center have been the "bottoms up" funding model in which faculty form the ARCs, up to three years of support for pilot studies, internal peer review of the ARCs, social networking in joint symposia and among trainees, seminars and research in progress meetings, and strong scientific mentorship by the leadership of the center. These interdisciplinary research centers can be supported at the departmental or institutional level (24).

Cross-Institutional Linkages: Schools in the health sciences such as public health, pharmacy, nursing, and dentistry, as well as schools in the arts and sciences (e.g., engineering, computer science, mathematics, and education) are increasingly important partners for faculty in clinical departments. Establishing joint appointments and leveraging shared interests, technical support, and interdisciplinary teams from these related fields are very useful approaches. Strategies to

integrate faculty in these diverse fields with faculty in medicine include: co-location of research programs, pilot grant funding that requires interdisciplinary participants, joint seminars and symposia, graduate students and post-doctoral fellows with faculty mentors from different disciplines, and joint or secondary faculty appointments (24). The social networking among students and fellows can be a particularly effective stimulus to interdisciplinary collaborations.

Recognition

The recognition of faculty working across disciplines, particularly in interdisciplinary research teams, can be challenging. Moreover, the work of these faculty may be slow to be recognized because they may be working outside their "home" clinical discipline (e.g., cardiology, pulmonary medicine, etc). Therefore, special efforts to support and recognize faculty working in emerging interdisciplinary areas requires additional thought and effort. Recognition of these faculty in the promotions process, through awards and honors, appointment to leadership roles, and in advocacy in national forums is essential to career advancement.

Promotion: Departments must carefully align processes of recognition and promotion with emerging and interdisciplinary research areas in order to retain faculty and develop high impact research. Because senior faculty on promotion committees may not fully represent the breadth of emerging research areas, the committees may be less familiar with the journals and the usual timelines of achievement. Therefore, insuring that promotion committees continuously review criteria for achievement in emerging fields and contain members with diverse backgrounds is particularly critical.

The importance of team science in determining success of research initiatives may obscure the contribution of an individual faculty member in the team, thereby making it difficult for promotion committees to fully recognize the achievements of individual faculty. Therefore, departments must be particularly diligent in providing supporting documentation of the contribution, impact, and accomplishments of individual faculty working in teams.

Awards and Honors: Faculty recognition in the breadth of academic fields in departments of medicine should include the establishment of departmental and institutional awards for achievement in a range of research methods and content areas. Some departments have also recognized interdisciplinary research through establishment of "Collaborator of the Year" or "Innovator of the Year Award". As with traditional biologically-based investigators, facilitating recognition of faculty through arranging speaking engagements and regional and national awards are very helpful.

Leadership Roles: Creation of new programs, sections, divisions, and centers led by individuals working in emerging areas can both accelerate program development and provide important opportunities for individual faculty. These individuals serve as critically important role models for trainees and faculty. Accordingly, appointment of individuals working in these areas to traditional departmental leadership positions such as vice chair for research, section chief, or unit director provides an important validation of these new fields. Consideration for joint appointments or cross-departmental appointments will also build recognition; for example, a vice

chair for research in a department of medicine whose home department is outside Medicine will exemplify the support and recognition of interdisciplinary research.

Advocacy: The leadership of successful research-intensive departments have emphasized the importance of many forms of discovery and avoided valuing some forms of research achievement more than others. Faculty and trainees may be inadvertently deterred from pursuing new areas of research if there is a real or perceived hierarchy of what is valued by their leaders.

Summary

Throughout their history, departments of medicine have tackled new opportunities in discovery and training. The availability of new techniques and technologies to answer important medical questions is accelerating at a breathtaking pace. Success in these emerging areas of research requires interdisciplinary collaboration on a much larger scale than in the past. The ability to recruit, develop, and promote faculty in these emerging areas will determine whether departments successfully embrace these exciting opportunities. We emphasize that new leveraging infrastructure and training paradigms, along with novel organizational approaches that catalyze interdisciplinary teams will continue to be critical to the success of faculty. As departments strive to develop excellence in new research areas, proactively encouraging and recognizing outstanding faculty achievement will continue to be very important. Over the past decade, departments have been aggressively pursuing evolving research areas that have potential to improve the prevention, diagnosis, and treatment of disease. An intense focus on the lessons learned in faculty development will determine our success in meeting this ongoing challenge. While many of the strategies outlined must expand beyond any individual department, departments of medicine have both a distinct opportunity and responsibility to their faculty and patients to lead in this effort.

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Table I

Examples of Emerging Areas of Research in Departments of Medicine

Health Services	New Forms of Clinical Trials
Integrative Epidemiology	Quality Improvement

Implementation Science	Natural Language Processing
Cost Effectiveness	Bioengineering
Patient-Centered Outcomes	Artificial Intelligence
	Cell and Tissue Engineering
Nanomedicine	Bioinformatics
Medical Informatics	

Table II

Summary of Strategies to Support Faculty in Interdisciplinary Research

- Training and Mentoring
- Research Cores
  - Instrumentation
  - Biostatistics
  - Bioinformatics
  - Medical informatics
- Organizational Structures
  - Interdisciplinary research centers
  - Interdisciplinary pilot grants, seminars, symposia
  - Cross-institutional linkages
- Recognition
  - Promotion
  - Awards and honors
  - Leadership Roles
  - Advocacy