

BUILDING BRIDGES BETWEEN BASIC SCIENCE AND CLINICAL MEDICINE: A LIBERAL ARTS PERSPECTIVE

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A – study design, **B** – data collection, **C** – statistical analysis, **D** – interpretation of data, **E** – manuscript preparation, **F** – literature review, **G** – sourcing of funding

ABSTRACT

A critical issue for improving global health care is to better integrate basic science and clinical practice, as such integration will lead to innovative solutions. In this article, I will present models for how to prepare students to participate effectively on multidisciplinary teams that foster cooperation between scientists, medical centers, biotechnology businesses, and governmental bodies. I will provide examples of training programs in the United States (USA) designed to increase the number of and diversity of scientists and clinicians engaged in bridging basic science and clinical medicine, also called translational research. The training programs target different stages in career development, from pre-medical students through early career faculty, and have varied organizational structures. Many of the programs have existed long enough for institutions to be able to evaluate their effectiveness, and despite the different program contexts, there are key characteristics common to all of the programs that correlate with successful outcomes. Many of these characteristics can be adapted to other career stages and settings. I will summarize these and describe an example of an interdisciplinary, integrated science course for undergraduates that introduces students at the earliest stage of their careers to addressing complex problems through teamwork. Finally, I will provide suggestions for how other institutions can implement training programs that will build bridges between basic science and clinical medicine.

KEYWORDS: translational research, training programs, interdisciplinary collaboration

BACKGROUND

Health care is a complex, multidisciplinary issue requiring innovation to improve patient outcomes while managing costs. My perspective is as a scientist and professor at a predominantly undergraduate liberal arts institution that sends many students to graduate and medical school. In the USA, the undergraduate years are a prime time for students to explore career options while gaining breadth and depth of academic learning. Therefore, it is important to make this population aware of opportunities to participate in finding innovative health care solutions, and to help prepare them to be effective contributors to interdisciplinary research teams.

TRANSLATIONAL RESEARCH

The Evaluation Committee of the Association for Clinical Research Training (ACRT) set forth a definition of translational research that has been widely

accepted in the USA [1]. “Translational research fosters the multidirectional and multidisciplinary integration of basic research, patient-oriented research, and population-based research, with the long-term aim of improving the health of the public.” The ACRT committee also provided a framework for designing and evaluating programs that focus on translational research.

WHY IS IT IMPORTANT TO IMPLEMENT PROGRAMS?

Institutions have developed programs to enhance translational research since they recognized that not enough scientists and clinicians were involved in such research, and that the institutions needed to foster their participation. Traditional training of scientists and clinicians does not include how to engage in translational research, and yet the skills necessary to develop successful translation researchers can be taught and

learned. Another reason to implement structured programs is that translational research requires interdisciplinary teams due to the wide range of skills needed to find innovative health care solutions (e.g. bioinformatics, high throughput approaches, legal, marketing, business plan development), and people in these different areas might not have easy ways to find each other and collaborate [2]. In the USA, there are significant disparities in access to healthcare and increasing the diversity of those involved in translational research is one way to address the problems. The biomedical challenges in search of solutions are multipronged, with societal and cultural factors essential components of any successful approach.

A further challenge to implementing novel approaches to health care is the gap between basic research and commercialization of a health care innovation. Knowledge necessary to bring a new product to patients, such as regulatory and intellectual property concerns, is outside of the scope of training in biomedical sciences; however, programs tailored to close this gap have been effective[3].

EXAMPLES OF TRANSLATIONAL RESEARCH PROGRAMS IN THE UNITED STATES

Universities and medical schools in the USA have developed programs to encourage health care innovation by bringing together teams with distinct areas of expertise. Some of the programs have a goal to increase the numbers and diversity of scientists and clinicians engaged in innovative translational research, while others focus more on bringing new solutions to the health care marketplace. One of the many advantages of putting a structured program in place is that institutions can evaluate them and determine what components work and what should change.

The National Institutes of Health (NIH) also has translational research as a priority and supports the NIH Clinical and Translational Science Awards (CTSA), run by a section of the NIH called the National Center for Advancing Translational Studies (<https://ncats.nih.gov/ctsa/about>) for institutions, and the Clinical Research Education and Career Development (CRECD) Program (R25) for individual researchers. Currently, the NIH funds 58 translational research “hubs” through the CTSA mechanism (<https://ncats.nih.gov/ctsa/about/hubs>). Institutions employ the funding in different ways (see [4], [5], [6] for examples). A hub at the University of Texas Medical Branch developed a multidisciplinary translational team (MTT) model for training translational researchers [4]. Their multi-faceted program recruits participants at different career stages, including graduate and health science students, early career investigators, and senior investigators from different departments, and does not focus on one specific area of translational research. Team science is a critical component of translational research and they create

structured teams that deliberately include a variety of viewpoints and career stages, and then provide ongoing training for how to work productively on a team. Their program also includes support and training for research mentors, recognizing the benefits of complementary mentoring models for trainees.

Increasing the diversity of participants in translational research is an explicit goal of a number of programs, including the CSTA-supported consortium of Emory University, Morehouse School of Medicine, and Georgia Institute of Technology in Atlanta, Georgia that focuses on training junior faculty through a two-year Master of Science in Clinical Research (MSCR) program [5]. The funding made it possible to give junior faculty time to develop an independent translational research program while advancing their careers [5]. The CRECD program supports a consortium of The University of Puerto Rico-Medical Sciences Campus (UPR-MS), a Hispanic public, academic health center, and Morehouse School of Medicine (MSM), a historically black private medical school, which emphasizes the recruitment and training of a diverse group of trainees through a post-doctoral Master of Science in Clinical and Translational Research (MSc) program [6]. These are two examples of programs that implemented master’s level training to provide coursework and structure for trainees.

Institutions have continued to design programs distinct from the CTSA and CRECD awards to advance technology and innovation in health care. Yale University established the Yale Center for Biomedical Innovation in 2014 to address the gap between basic research and commercialization of health care solutions [3]. They drew on the experiences of other such Health care Innovation Centers (HIC), including a partnership between Massachusetts Institute of Technology (MIT) and Harvard University, and a center at Stanford University. These HIC provide expertise in an array of issues, from intellectual property and market assessment to institutional review board processes in addition to bringing scientists and clinicians together. One component of Yale’s and others’ programs is the “Hackathon” model for generating ideas; the center identifies an unmet need, and teams apply to participate in problem solving, with the incentive of financial and other support for developing the innovation further. The Yale Center and other HICs include courses and programs for a wide range of students, faculty, and staff throughout the university and serve as examples of institutions taking a multi-pronged approach to health care innovation.

Some programs focus on graduate and medical student trainees, with the goal of enhancing students’ translational research skills and interests early in their careers. Begg and colleagues analyzed programs designed to open the pipeline to translational research from graduate students [7]. They recognize the tension between the depth of discipline-specific expertise required for Ph.D. students and the interdisciplinary training needed for translational research; they iden-

tify additional training opportunities through courses and seminars in multiple disciplines, interdisciplinary courses, laboratory and field experiences, and interdisciplinary team projects [7].

WHAT SKILLS AND ATTITUDES SHOULD STUDENTS HAVE BEFORE THEY START THEIR GRADUATE MEDICAL TRAINING THAT WOULD LEAD THEM TO BE INNOVATIVE AND EFFECTIVE PARTNERS IN TRANSLATIONAL RESEARCH?

Many of the programs have existed long enough for institutions to be able to evaluate their effectiveness, which they measure in a variety of ways, such as through survey data about interdisciplinary and translational research, publications, new therapy development, and career trajectory [4,5]. Evaluation of current programs in the USA designed to increase the number of translational researchers has shown a few key characteristics of successful programs. Effective communication, a truly multidisciplinary and diverse team, training for the mentors and teachers, and institutional commitment are all important factors in success.

COMMUNICATION

Assessment results from varied programs show that communication skills are critical for a team's and individual's success [4, 8]. Most programs begin with teaching every participant how to have productive conversations with team members from different backgrounds and career stages. A straightforward aspect is learning to avoid discipline-specific jargon, which sets up barriers to communication and can establish a competitive rather than cooperative atmosphere. Participants also learn how to listen; people may think they already know how to listen and participate in meetings, but the skills of active listening and allowing participation by all team members is an essential skill that can be taught by people trained in group dynamics and communication.

Another aspect of communication is public speaking, and most programs also teach how to give presentations and provide many varied opportunities for participants to practice speaking, whether through conferences or community outreach. In some programs, leadership development incorporates training in communication [4].

STRUCTURED MENTORING

While the teams address an array of topics, all have shown that structured mentoring is important [4,5,6]. The role of mentors may include assistance with study planning and design, and review of grant drafts and manuscripts. Mentors usually provide general professional advice, encouragement, and feedback. Training

for mentors is important since they learn how to give feedback and how to be good mentors through regular, constructive communication, helping mentees and teams achieve goals. Mentoring is not unidirectional, from professor to student/trainee; rather, the mentor should be open to learning from the student, and peer to peer mentoring is also valuable.

COURSEWORK AND INNOVATIVE PEDAGOGY

Many programs incorporate coursework in areas that many trainees would not have had prior to participation in the program, such as basic computer science and bioinformatics in addition to the teaching of communication and leadership skills. Ideally, undergraduate students would get some exposure to these topics, either at their university or through summer research. Durairajanayagam and colleagues describe a summer undergraduate research program at the Cleveland Clinic with the explicit goal of recruiting physician scientists to pursue translational research [9]. Their program includes coursework in the scientific underpinnings of the research project, scientific writing, hands on experience at the bench, and communication skills. Surveys of participants suggested that all aspects of the program were of value, but especially the training in scientific writing and oral communication [9]. This program is relatively small, and it would be beneficial for many undergraduates to have such an experience.

One way to increase the number of undergraduates who have the skills and interests to engage in interdisciplinary team-based translational research projects is to incorporate training into regular coursework. In the Keck Science Department of Claremont McKenna, Pitzer, and Scripps Colleges, we designed and implemented an interdisciplinary introductory course, Accelerated Introductory Science Sequence (AISS) with support from the National Science Foundation, that combined biology, chemistry, and physics in a novel way [10]. Students learned how to tackle complex, multidisciplinary problems through teamwork, both through problem-based learning in the classroom and in the lab. The innovative pedagogy incorporates many of the skills needed for translational research, and a higher percentage of students who took the course pursued interdisciplinary science majors relative to those who took the traditional format [10]. We have been able to expand the model to reach more students, by combining two disciplines rather than three at a time, while continuing the emphasis on interdisciplinary science and teamwork.

INSTITUTIONAL SUPPORT FOR PROGRAMS THAT FOCUS ON TRANSLATIONAL RESEARCH CAREER PREPARATION

A finding common to successful programs is that the institution is fully committed to the program's suc-

cess. The institutional leadership must demonstrate commitment by rewarding those who participate and explicitly valuing interdisciplinary projects. Institutions must provide financial support for the programs that build on external funding. The best programs include training in communication, mentoring, and writing in addition to tackling important health care issues; they also include a robust assessment plan and program coordinators, all of which require institutional funding. Measuring and communicating program outcomes within and beyond the university community is beneficial for recruiting new team members, raising the profile of the participating institutions, and potentially for attracting additional funding.

Institutions must provide incentives for participation; for example, faculty who serve as mentors or are junior researchers taking advantage of the training opportunity must have confidence that engaging in translational research is beneficial rather than harmful for their career. Multidisciplinary teams result in multi-author publications, and committees that review faculty for appointment, promotion, and tenure must recognize the value of interdisciplinary, team-based research, and administrators (provosts, rectors) must communicate to these review committees why translational research is important for the institution. The trainees must be able to see how the addi-

tional or different training provided by a translational research program will enhance their career prospects, whether by making them more competitive for post-doctoral or residency programs, grants, or positions in industry.

CONCLUSION

Institutions in the USA have developed translational research training programs for students and faculty at different career stages. Many have established health care innovation centers as well, explicitly bridging the health care and business sectors. Commitment from the NIH has been essential for institutions to create multi-institution partnerships and to set national standards for expectations of such programs. Many of the lessons learned from these programs and centers in the past decade are instructive for institutions outside the USA that are starting translational research programs. While there will be site-specific concerns, all programs should incorporate communication skills, structured interdisciplinary teams, and mentorship training. In addition, the institutions involved must be fully committed to the programs, as demonstrated by financial and policy decisions, and governmental support should help further the goals of improving health care through innovative translational research.

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