Biomedical Informatics in the Education of Physicians

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When I first meet with preclinical medical students, I make a point of asking them what they believe will receive the greatest focus of their attention once they are in clinical practice. The most common response, not surprisingly, is patients, and yet it is clear to experienced practitioners that the correct answer is information—in the service of their patients. The need for information underlies essentially all clinical work: the questions asked during a patient history, the tests ordered, the books read, and the questions asked of colleagues. A key correlate to information is knowledge, that elusive concept that justifies all the years of education and training, and that provides the background sense of what is true that allows gathering and interpreting information appropriately. Clinicians often start with data (eg, "Mr Jones' creatinine is 5.2 mg/dL"), those individual elements that combine to allow a synthesis of observations with what is known in order to create summary statements of information (eg, "Mr Jones has renal failure").

Despite the central role of data, information and knowledge in health and medicine management and use of such concepts has generally not been singled out as a subject of study during medical education. Medical students gather data, access information, and apply the remarkable amount of knowledge that they are acquiring but tend not to study these notions as formal concepts. Much is left to osmosis, abstract introspection about good judgment, and observation of mentors. These issues are touched on when teaching clinical decision making—test interpretation and predictive value, cognitive biases, and the like—but a coherent approach to information and knowledge management and their application has generally not been part of medical education.

The notion that these concepts can be independently studied and taught was energized in the last half century by the rapid proliferation of information technology and its gradual adoption in health care settings. Today, information and knowledge management are often equated with the role of computer systems, although the concepts have been relevant to clinical practice since the time of Hippocrates. A formal discipline has emerged over the last few decades,[1] initially termed "medical informatics" but subsequently broadened to "biomedical informatics" when its relevance to the basic medical sciences, as well as clinical sciences, became clear. A recent consensus process by the American Medical Informatics Association has resulted in the following evolving definition of the field, which notably does not include any mention of the computing technology that is often a modern external manifestation of the discipline: "Biomedical informatics . . . is the interdisciplinary, scientific field that studies and pursues the effective uses of biomedical data, information, and knowledge for scientific inquiry, problem solving, and decision making motivated by efforts to improve human health."[2]

Biomedical informatics is generally viewed as having 4 major areas of application: (1) molecular and cellular processes: bioinformatics; (2) tissues and organ systems: imaging informatics; (3) individuals and patients: clinical informatics; and (4) populations and society: public health informatics. Together, the latter 2 areas are often referred to as health informatics. Other informatics areas are generally subsumed by 1 of these areas (eg, nursing informatics) or are at intersections among 2 or more of them (eg, biomolecular imaging, pharmacogenomics, or consumer health informatics). Cross-cutting methods, such as cognitive science, can play a central role in medical education broadly, as well as in biomedical informatics.[3]

Given the central role of informatics notions in clinical practice, including health care technology, many observers have argued that the discipline ought to be taught to physicians in training, from the preclinical years through graduate medical education and beyond.[4] The Association of American Medical Colleges first called for inclusion of informatics in the medical curriculum in the General Professional Education of the Physician report in 1984.[5] Informatics education has been embraced by colleagues in nursing education more extensively than in medicine, with nursing informatics now generally a standard component of the

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curriculum.[6] With curricula that are already overfull and a resulting lack of enthusiasm for adding new topics, the introduction of biomedical informatics education in medical schools has been more limited. One new medical school, unconstrained by an existing curriculum and traditional time slots for courses, has found it easier to introduce significant formal training on informatics topics into its curriculum.[7]

What do medical students need to learn about biomedical informatics? By analogy with pharmacology, they need to know both the practical applied side of informatics and the core conceptual notions that will remain valuable long after current applications are antiquated. Courses in pharmacology teach about specific drugs and their use but also about core notions of pharmacology such as structure-activity relationships, drug design methods, tolerance, addiction, and toxicity effects. Informatics has a core science, elements of which will be valuable to physicians throughout their careers, whatever their specialty choice. Anecdotal evidence of this claim includes the question that frequently occurs in biomedical informatics continuing education courses: "Why didn't they teach me this in medical school?"

Medical students need to learn about MEDLINE searching, the value and role of bibliographic databases as opposed to Google searches, the role of order-entry systems, electronic health records, regional data exchanges, telemedicine, and other important but current issues in the application of informatics in health and medicine. However, students also need to understand key underlying notions such as data privacy and confidentiality, conceptual errors in judgment, flaws in information and how to anticipate and deal with them, reasoning methods and opportunities for bias, principles of effective interactions between human beings and technology, and the role of human factors and usability research in the creation of effective, efficient, and accepted information aids. Students do not need to become computer programmers nor do they need to design systems, but they do need to be informed consumers who understand both the power and vulnerabilities of the tools they will be using in their practices.

The challenge is to blend such topics effectively into the existing medical education environment and to sustain understanding of these topics throughout residency training and beyond. There are curricular design obstacles, given the burgeoning number of relevant topics for future physicians, as well as challenges in identifying or recruiting faculty members who can teach such topics effectively and in a way that sustains a sense of relevance to students who are focused on their future clinical roles. Biomedical informatics is not a topic that is optimally taught in a single course during the preclinical years but rather should be blended into the 4-year curriculum with evolving topics and the use of clinical examples and challenges to motivate and direct the grasp of informatics concepts.

Despite recent efforts to increase the health information technology workforce, there are too few trained biomedical informatics scientists who can join faculties, pursue research, and teach medical and graduate students. Some physicians have sought graduate training in biomedical informatics, sometimes with a full residency and fellowship. However, this expertise is not created quickly, and the demand for such specialists has only increased with the recent proliferation of National Institutes of Health–funded Clinical and Translational Science Award programs,[8] all of which require biomedical informatics as a core resource. The rapidly increasing number of academic biomedical informatics programs in medical schools is testimony to this phenomenon, but many schools have had difficulty filling leadership positions with the kinds of scholars, educators, and innovators they need. Recent efforts to create accredited fellowships and a formal subspecialty board in clinical informatics may help to increase the number of faculty members for such roles,[9] but more graduate education programs and more positions in those programs that do exist are needed.[10]

Despite the challenges, the current transition in biomedical informatics is exciting and transformative. It portends a day when clinicians will recognize that they have needed and used their education in information science as well as basic and clinical sciences. All 3 are important in the education of 21st century physicians.

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