Commentary: **Informatics in Biomedicine and Health Care**

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Abstract

During the last two decades, biomedical informatics (BMI) has become a critical component in biomedical research and health care delivery, as evidenced by two recent phenomena. One, as discussed in the article by Bernstam and colleagues in this issue, has been the introduction of Clinical and Translational Science Awards. Perhaps even more important has been the recent, arguably long overdue, emphasis on deployment of health information technology (IT) nationally. BMI utilizes IT and computer science as tools and methods for improving data acquisition, data management, data analysis, and knowledge generation, but it is driven by a focus on applications based in deep understanding of the science and practice, problems, interactions, culture, and milieu of biomedicine and health. Building from Bernstam and colleagues' distinction between BMI and other IT disciplines, the authors discuss the evolving role of BMI professionals as individuals uniquely positioned to work within the human and organizational context and culture in which the IT is being applied. The focus is not on the IT but on the combination—the interactions of IT systems, human beings, and organizations aimed at achieving a particular purpose. There has never been a time when the need for individuals well trained in BMI—those who understand the complexities of the human, social, and organizational milieu of biomedicine and health—has been more critical than it is now, as the nation seeks to develop a national infrastructure for biomedicine and health care, and as these fields seek to broadly deploy IT wisely and appropriately.

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In 1990 we described biomedical informatics (BMI) as an "emerging" discipline and institutional priority.[1] Although it is possible to trace the roots of the field to the late 1950s[2] and to an explosion of seminal work in the 1960s,[3] at the time our article was published it had taken 30 years for the field to become established with the formation of early academic units and formal graduate degree programs at several medical schools and health science universities in the United States and elsewhere. At that time we referred to the field as "medical informatics" because the article predated the torrent of activities in genomics and proteomics and the extensive development of the field of *bioinformatics*, which deals with the information needs of those activities. Today, BMI encompasses a variety of subdisciplines—addressing informatics problems and challenges at the molecular level via *bioinformatics*, at the organ/tissue level via *imaging informatics*, at the person level via *clinical informatics* (including dental, nursing, consumer, and other special foci), and at the population level via *public health informatics*.[4]

During the last two decades, BMI has not only "emerged" but has become a critical need, brought to the fore by two recent phenomena. One, as discussed in the article "Synergies and distinctions between computational disciplines in biomedical research: Perspective from the Clinical and Translational Science Award programs" by Bernstam and colleagues[5] in this issue, has been the introduction of Clinical and Translational Science Awards (CTSA) and the recognition by academic institutions that CTSA support is dependent on mounting a credible program in biomedical informatics research and support. Perhaps even more important has been the recent, and arguably long overdue, emphasis on deployment of health information technology (IT) nationally. As a major agenda of the Obama administration, and through the American Recovery and Reinvestment Act (ARRA), unprecedented funding is now available to address the role of IT in health care practice and public health, including the deployment and support of operational systems for these purposes. The important need for workforce enhancement in health care IT has also been acknowledged, including a growing recognition of the need to incorporate informatics topics and concepts into health professions education. The support from the recent economic stimulus package for the National Institutes of Health includes programs that will enhance the role of informatics in support of biomedical research and, to some extent, for innovative research in informatics itself.

BMI as a field is concerned with the methods and capabilities for developing models for the understanding of biomedical and health systems and processes, acquisition of data characterizing those systems and processes, representation of these data, storage of the data, analytic processes for using these data, generation of knowledge from data, management of the knowledge, and application of the knowledge to facilitate problem solving, decision making, optimization of processes and workflow, and other tasks. It is also concerned with the social, cultural, cognitive, organizational, and

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educational requirements for effective use and application of data and knowledge.

Thus, BMI utilizes IT and computer science as tools and methods for developing and applying such capabilities, but it is driven by a deep understanding of the science and practice, problems, interactions, culture, and milieu of biomedicine and health. It is also informed by cognitive science, decision science, computer science, statistics, management science, social science, ethics, and a variety of other fields.

The article by Bernstam and colleagues[5] refers to BMI as one of several *computationally* oriented disciplines. A recent National Research Council (NRC) report by Stead and Lin[6] refers to "*Computational* Technology for Effective Health Care: Immediate Steps and Strategic Directions" [italics added]. We submit that the emphasis by both on "computation" somewhat distracts from the point and the essence of BMI, an emphasis that accounts in part for the confusion regarding the distinction between *biomedical informatics* as a discipline and *health care IT*. It is important to understand that the role of BMI is in understanding the information and decision-making needs of researchers and practitioners in biomedicine and health and in developing and applying methods and procedures to help meet those needs. Some, in fact most, of the ways in which these needs are addressed today will indeed involve computation, but the aspects of information handling, interoperability, and application are vital and are not conveyed adequately by the term "computation."

Bernstam and colleagues seek to distinguish BMI researchers and practitioners from IT professionals and computer scientists. This is difficult in part because many individuals now being trained in BMI will actually function in health and biomedical IT roles, as managers, analysts, and developers. Many individuals trained in computer science also play these roles and may secondarily receive formal training in BMI, but they often obtain BMI understanding and skills on the job. What BMI training and experience bring to these activities is the human and organizational context and culture in which the IT is being applied. The focus is not on the IT but on the combination—the interactions of IT systems, humans, and organizations aimed at achieving a particular purpose. Some BMI practitioners, in fact, will focus on the IT aspects, whereas some—such as those interested in cognitive science and those coming from the health care professions—will tend to focus on the human interaction, use, evaluation, and acceptability of the application. Others—such as those with business and management skills and training—will focus on the organizational adaptations, systems, workflow, and cost-effectiveness aspects of an application.

It is helpful to recognize that individuals trained in BMI may have roles that range from research to practice, and also roles that involve varying degrees of leadership. Bernstam and colleagues tend to focus in their article on BMI as playing primarily a research role, but training in BMI, and the understanding of the human and organizational aspects of biomedicine and health that this entails, are essential underpinnings for individuals who have the more applied roles discussed above. The career paths for graduates of BMI training programs bear out this point; the majority of graduates go into applied roles in health care, industry, government, or the military rather than into academia or research institutes.

Bernstam and colleagues correctly identify computer science as an academic research discipline, but of course many graduates of the discipline go on to applied positions in industry or government. To the extent that computer scientists take on biomedically related research challenges, or apply their work in health care settings, BMI professionals have another important role to play—that of mediator and collaborator between the world of computer science and the world of biomedicine. This point was stressed in the NRC report mentioned above,[6] which also emphasized a number of computational "grand challenges" in health care to which the computer science research community could beneficially turn its attention.

The distinction between a Clinical Data Repository (CDR) and the Clinical Data Warehouse (CDW) example used by Bernstam and colleagues can be used to highlight a key point we are making. A CDR is typically developed in a health care delivery system as a means for assimilating the continual stream of transactions involved in patient care, involving a variety of different kinds and sources of data and maintained on a per-patient basis. In a well-designed and implemented CDR, the patient-specific data will typically be derived and unified from a variety of "feeder" systems, such as the clinical laboratory, radiology, transcription, the admitting office, and a system for accepting and conveying physicians' orders. A CDR enables clinicians, for example, to be able to view various aspects of a patient's prior history and results, current orders, and trends, and to facilitate care by providing decision support, workflow support, quality and safety monitoring, and other functionalities. Typical electronic medical records (EMRs) provide a means for examining the data in a CDR, and usually for adding information based on a clinician's own observations.

A biomedical or health care researcher, or public health specialist, by contrast, is interested in accessing data aggregated across multiple patients by characteristics such as specific demographics, particular tests, procedures, and treatments, and particular results or the same diagnosis, to aid in identifying associations, assessing effectiveness of predictions, or determining patterns of utilization. To support such functionality, it is important to have a *data warehouse*, like the one described by Bernstam and colleagues, that enables such aggregations to be done efficiently, to support exploratory query and investigation, to provide means for deidentifying patient data when appropriate, and to support controlled release of identifiable data for more detailed study.

The clinical transaction focus supported by a CDR is different from the kinds of queries and studies an investigator or administrator needs. The architecture of a data warehouse is accordingly different from that of a CDR, organizing the data along the dimensions corresponding to the different attributes of groups of patients rather than organizing them by patient. The efficiency of achieving these different uses depends on architectures optimized for their specific purposes. Moreover, trying to do research on aggregate data using a CDR would severely compromise performance of the database and associated EMR for clinical purposes. A BMI professional has an understanding of these distinct purposes, the rationale for two parallel data systems, and the nature of the users and organizations needing them. Such individuals are thus in an excellent position to define the IT requirements to satisfy each, to help guide the design and configuration of systems for each purpose, and to determine how they should relate to one another.

Although Bernstam and colleagues focus on the clinical and translational science perspective, the need for clarity about BMI is even more essential given the impetus of the ARRA initiatives that have moved the role of BMI practitioners and researchers to the forefront in our national discussion of health reform and economic stimulus. There has never been a time when our need for individuals well trained in BMI—those who understand the complexities of the human, social, and organizational milieu of biomedicine and health—has been more critical than it is now as the nation seeks to develop a national infrastructure for biomedicine and health care, and as we seek to deploy IT wisely and appropriately on a broad scale.

References

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