Survey of biomedical and health care informatics programs in the United States

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INTRODUCTION

Informatics, in the classic definition, is a science that studies ''the representation, processing, and communication of information in natural and artificial systems'' [1] or, more pragmatically, ''a discipline focused on the acquisition, storage, and use of information in a specific setting or domain'' [2], such as health care or biomedical sciences. Informatics is also increasingly described as a profession that is still at the early stages of development [3]. There is continuing self-identification of different subfields of informatics, particularly those related to biomedicine and health care, both as scientific disciplines and as professions. One aspect of defining a profession or a subspecialty within it is establishing a set of agreed upon competencies and corresponding educational curricula [3]. Yet, while the number of programs ''with 'informatics' in their names'' is growing, these programs vary substantially in level and scope [4].

Our survey attempts to provide a snapshot of the current picture of informatics training programs related to biomedicine and health care in the United States. The purpose of the survey is twofold. First, the survey is intended as a resource for students, educators, and informatics professionals. Second, through compiling detailed information about existing educational opportunities, we attempt to contribute to the definitions of various informatics subspecialties.

This is the fifth generation of surveys of informatics programs conducted by our research group; previous surveys were published online [5]. The first three surveys, carried out annually in 2002–2004, focused only on bioinformatics programs. In more recent iterations (2006 and current, 2008, versions), we moved to a biannual schedule, but broadened the survey scope to encompass medical, health, nursing, dental, and other related informatics programs. In the latest survey presented in this paper, we have also significantly expanded the information categories used to describe each program and paid special attention to grouping the program listings to better correspond to the various informatics subdisciplines. A number of web resources provide similar information, such as the International Society for Computational Biology's listing of degree and certificate programs [6] or the American Medical Informatics Association's list of training programs [7]. Our survey differs from such resources in several important ways: It cuts across the diversity of biomedical and health informatics subspecialties; it provides specific and detailed information for each program; and it presents the information in a way that facilitates comparison of programs within and between subspecialties.

METHODS

The program listings, organized by institution, compiled in 2006 [5] served as the starting point of information gathering. Information about existing programs was verified and updated as needed. A series of Google searches using combinations of keywords similar to the ones described by Hemminger and colleagues [8] were carried out to locate programs that were new or that have been missed in the previous surveys. Between survey publications, we also received suggestions for new programs to include or updates to program listings, which we reviewed and included as appropriate.

Searching for informatics program web pages potentially has limitations in identifying all current programs. However, the number of direct requests for additions between biannual surveys is usually only three to four, with most programs suggested this way having been already identified via our current search methodology for the next survey update. This information gives us confidence that our latest survey is sufficiently comprehensive and captures information about the vast majority of existing informatics programs.

Extensive browsing and keyword searching of program web pages was conducted to verify and update program information details. The informatics categories used to describe the programs have been revised and expanded in the current survey to provide a more nuanced picture of each program. Those additional information categories are italicized below. The survey includes state, institution name with a link to the main program web page, degrees offered, departmental affiliation, admission requirements, degree requirements, *program cost*, *target audience*, *specific skills of graduates* (program focus), *sample course titles*, links to web pages with course listings, sampling of research interests, *grant funding*, *funding opportunities for students*, *program delivery format*, year program was established, and other information (such as special prerequisites or part-time study options), as well as technical notes about the survey.

In the current survey, we substantially revised and finetuned the logic for including each program into an informatics subcategory. These categories are: bioinformatics, cheminformatics, medical informatics, nursing informatics, dental informatics, health informatics, and pharmacy informatics. The placement of each program into one of these categories was based primarily on a combination of the program name and the degrees offered, with attention to the curriculum and schools or departments that house the program. A detailed description of rationale for program categorization can be found on the survey website [5] by clicking on ''Survey Methodology'' button.

It is worth noting that a few informatics programs have very diverse sets of educational options (e.g., bioinformatics and clinical informatics tracks in one program or biomedical and health informatics combined into one curriculum). These programs were cross-listed between informatics subcategories but counted only once for the purpose of reporting the survey results. Otherwise, every effort was made to list programs singly based on the primary focus of a given program.

RESULTS

The complete results of the current survey, which include information on 177 programs, are available online [5].* Each program is described in two formats: a detailed listing of all the surveyed information in an Excel spreadsheet and a brief version with key information presented on a single web page for easy browsing.

Overall, comparing the results of this survey with those from previous years shows that informatics, as a field, is still evolving. These evolutionary changes include discontinuation of some programs and establishment of new programs as well as emergence

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* The program summaries are based on what was published on the web at the time the survey was conducted (October to December 2008) and should be seen as a time-specific snapshot.

Table 1
Number and level of degrees offered by different categories of informatics programs

Degree levels in each program	Informatics program category						
	Health*	Medical†	Nursing‡	Bioinformatics§	Cheminformatics**	Dental**	Pharmacy**
Bachelor's	3			12	1		
Bachelor's and master's	2	1		5			
Bachelor's, master's, and PhD				7			
Graduate certificate	6	1	2	3			
Graduate certificate and master's			6	5			
Graduate certificate, master's, and PhD		4		3			
Master's	14	6	11	16			
Master's and PhD	7	5	1	21	2	1	
PhD		3		19			
Residency or fellowship						1	9
Totals	32	20	20	91	3	2	9

* Programs titled as and/or offering degrees or specialization in health or public health informatics.
† Programs titled as and/or offering degrees in medical or biomedical informatics.
‡ Programs offering advanced nursing degrees with an informatics component, are affiliated with a nursing school or department, and are accepting students with nursing experience.
§ Programs described as "bioinformatics" or "computational biology" and offering degrees in these or related fields with relevant focus or specialization.
** Programs titled as and/or offering a degree or specialization in cheminformatics, dental, or pharmacy informatics, respectively.

of new subfields, such as dental informatics, which is similar to medical informatics but focuses on dentistry-specific issues, and cheminformatics, which is similar to bioinformatics but has a stronger emphasis on chemistry and pharmacology. At the same time, the more established informatics subdisciplines—namely, health, medical, and bioinformatics—are beginning to mature and adapt to the needs of the practice community by offering more nonresearch degree options such as graduate certificates and professional science master's (PSM) programs. There is generally a notable expansion of the variety of the degree offerings in existing programs. For example, of the bioinformatics programs listed in both the current survey and the one conducted in 2004 [8], 10 have added 1 or 2 new degree options. The same 2004 survey listed 80 programs in both medical and bioinformatics, compared to 111 such programs in the current survey. Given that the same survey methodology has been applied in both surveys, this suggests an overall growth in these fields.

As illustrated in Table 1, the availability of educational opportunities varies substantially between the informatics subspecialties in both the number of programs and the degree levels. Of the 177 programs surveyed, the majority (91) fall into the bioinformatics category. The latter includes both bioinformatics and computational biology degree programs due to curricular similarities between the two. Very low numbers for dental and cheminformatics programs indicate the emergent nature of these subspecialties. While the total number of programs in health and nursing informatics is similar to the previous (2006) survey [5], there appear to be ongoing adjustments in these areas with a few programs being in decline and others having just been established or redefined (e.g., a nursing informatics program being redesigned as a health informatics program with a broader scope).

In terms of level of education, most informatics offerings are at the graduate level, but there is a trend toward offering undergraduate degrees, particularly in health and bioinformatics. Bioinformatics presents the most diverse set of educational options and, in some cases, offers bachelor's through doctoral degrees in the same program. Conversely, pharmacy informatics programs offer only postgraduate, research-oriented training. Medical informatics programs present a mix of practice-oriented and research-focused programs, while health and nursing informatics programs typically have a stronger practice orientation. This is reflected in a relatively higher proportion of programs offering certificates, a lower proportion of programs with doctoral degrees, and the absence of doctoral-only programs, which are common in the areas of medical or bioinformatics.

There are also notable differences between informatics subspecialties in terms of their affiliation with academic units. Nursing, dental, and pharmacy informatics programs are discipline specific in being affiliated with nursing, dental, and pharmacy academic units, respectively. Health, medical, and bioinformatics programs, on the other hand, can be housed in a variety of academic units and can be described as progressively more interdisciplinary. Health informatics programs are most likely to be affiliated with allied health and health sciences (31%), medical (25%), or public health or information or computer science schools (16% each). Medical informatics programs, predictably, are most commonly housed in schools of medicine or medical centers (45%), but a substantial fraction of the programs is interdepartmental (30%), with less common home bases including allied health and engineering. Bioinformatics programs are most likely to be interdepartmental or interdisciplinary (37%) but are also housed in biology (21%), computer or information science (13%), and medical schools (10%).

CONCLUSIONS

Our published survey summary is unique in providing information about educational options for multi-

ple subfields of informatics in a uniform format, which facilitates comparison across the informatics subspecialties. In addition to being a useful resource for informatics students and educators, the survey contributes to the discussion of the definitions of various informatics specialties in a pragmatic bottom-up fashion. By summarizing characteristics of various informatics educational programs, we provide a partial answer to the question posed by Hersh, "Who are the informaticians?" [3]. Our survey suggests that this answer will need to be subspecialty specific rather than general due to substantial differences in educational offerings among the health and biomedical informatics disciplines. To refine the answer, we plan to continue our work using a grounded theory approach to conduct a detailed course-level comparative analysis of curricula across all the informatics programs included in our survey.

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