The Emerging Field of Informatics

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The field of health care informatics brings together the various health sciences (eg, medicine, nursing, public health) and other relevant fields including information science, computer science, and cognitive science. The focus of this emerging field is to promote the effective organization, analysis, management, and use of information in health care in order to facilitate optimal health care delivery.[1,2] An important mission of the informatics field is to prepare practitioners to utilize health data for direct care as well as in support of optimal health services organization and delivery, public health surveillance and practice, and clinical research. In this article we describe how the field has developed and how clinicians and health care managers are being prepared to make the best use of data.

Early applications of information technology in health care began in the 1960s with a focus on financial (eg, generating a bill) and clerical (eg, admission, discharge, and transfer transactions) systems. These systems typically ran on large mainframe computers and produced basic management reports but often lacked the flexibility to produce customized reports. They were organized around generating a bill for a health care encounter as opposed to providing a longitudinal view of patients' health. With the introduction of powerful personal computers and networking technologies in the 1980s came the development of more clinically-oriented computer systems for health care. These systems were also more robust in supporting administrative functions.[3] Early clinical applications included laboratory results reporting and order entry systems; administrative applications included human resources, materials management, and project management systems.

As the field of health care informatics continued to develop, more vendors entered the health care information technology (IT) environment. The health care IT companies offered an expanded array of products including computerized provider order entry, clinical documentation (eg, physician and nurse notes), and specialized systems for areas such as the emergency department, the pharmacy, and the operating room. More recently, the field has grown to include bioinformatics applications which have been developed to manage the large quantity of genomic and other basic scientific data.

During this time researchers began to study the impact of clinical IT systems on the health care delivery system and eventually on patient outcomes.[3] These studies identified best practices and systems for health care IT design, integration with clinical workflow, and implementation.[4] Outcome studies showed the greatest impact on patient outcomes from computerized provider order entry and clinical decision support tools embedded in the IT systems.[5-7] Currently there are many large health care IT initiatives aimed at improving patient outcomes and reducing errors through well-designed decision support applications. Examples of such applications include drug-drug incompatibility alerts to providers during electronic prescribing and the use of standardized order sets.

"As the health care informatics field has developed, there has been recognition of the need to prepare informatics experts in both the clinical and managerial ranks."

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How We Teach People How To Use Data

Formal Informatics Education

Many of the early pioneers in health care informatics came from various clinical and technical fields and learned informatics on the job. Formal degree-granting educational programs in health care informatics began in the 1970s with a variety of foci such as health administration, clinical sciences (eg, medicine, nursing, pharmacy), computer science, bioinformatics, and public health.

National organizations have begun to develop recommendations for health care informatics content in the curricula for various professions. This emphasis on preparing practitioners to address informatics is an outgrowth of recommendations by the Institute of Medicine of the National Academies' 2003 report *Health Professions Education: A Bridge to Quality*.[8] This report was issued partly in response to the Institute of Medicine's 2001 report, *Crossing the Quality Chasm*, which focused on safety and quality of care.[9] In the 2003 report, the IOM recommended 5 core competencies that all clinicians should possess in order to meet the needs of the 21st century health system. One of those 5 is to utilize informatics to "communicate, manage knowledge, mitigate error, and support decision making using information technology."[10] These recommendations have spawned many educational initiatives directed at health professionals including the American Medical Informatics Association (AMIA) 10x10 Program, the goal of which is to train 10 000 health professionals in basic informatics content by the year 2010.[11] Though AMIA is just beginning to delineate core informatics content for physicians, it has partnered with leading academic informatics programs to deliver the 10x10 continuing education programs and short courses in both clinical and bioinformatics. This initiative is using curricular content from existing informatics training programs, distance learning, and other innovative educational strategies to deliver quality education to busy working professionals. A sample of key content from some of the clinically-oriented 10x10 programs is shown in Table 1.

Several of the content areas address preparation of practitioners for utilizing health data effectively including evidence-based medicine, data mining of databases/data warehouses, information integration and knowledge management, and data standards.

The National Library of Medicine (NLM) of the National Institutes of Health began funding medical informatics research training programs in the 1990s and currently funds 20 university-based programs.[12] Their goal is to advance the scientific basis underpinning the informatics field by training researchers. Some of these programs provide tuition and even stipends to health professionals wishing to gain expertise in informatics research. North Carolina participated in a joint Duke University and University of North Carolina at Chapel Hill medical informatics training program in the 1990s, but the formal NLM-sponsored program was discontinued in the early 2000s. Both universities continue to offer various types of education in health care informatics.

Informatics Competencies and Certifications

There are national recommendations for informatics competencies and certifications for many professions including nursing and health management. There is currently an effort to develop similar structures for physicians. The American Medical Informatics Association has received a grant from the Robert Wood Johnson Foundation to establish a subspecialty of applied clinical informatics in medicine which will include a certification process for physicians.[13]

The National Center for Healthcare Leadership has established a set of competencies for graduates of health care management programs.[14] Competencies that are relevant to informatics include data analysis, manipulation, understanding, and ability to explain data.

Specific informatics competencies for nurses are also being developed based on recommendations from the Institute of Medicine of the National Academies.[15] The competencies include skills, knowledge, and attitudes that are clinically-oriented as well as some that emphasize use of data for supporting safe processes of care and metrics for monitoring health outcomes. Nurses can achieve certification in the specialty of Nursing Informatics through successful completion of an examination.[16] Table 2 includes the key content included in this Informatics Nurse certification offered by the American Nurses Credentialing Center.

Table 1.
Informatics Content From Various American Medical Informatics Association 10x10 Programs[11]

Discipline overview, history
Evidence-based medicine
Role of information and technology in improving health care efficiency and quality
Databases, data warehouses, and data mining
Data standards
Decision support
Privacy, confidentiality, and data security
Information integration and knowledge management
Networking and telemedicine
Information system planning and project management
Clinical and administrative information systems
Electronic health records
Computerized provider order entry
Consumer health informatics

Table 2.
Informatics Content For Nursing Informatics Certification

Systems life cycle Systems planning, analysis, and selection
Systems design
Systems implementation and testing
Systems evaluation, maintenance, and support
Human factors (eg, usability)
Hardware, software, and networks
Data standards
Security
Data aggregation, warehousing, and mining
Knowledge generation (outcome probabilities, expert and rule-based systems)
Professional practice, trends, and issues
Models and theories (eg, change theory)

Content areas such as data standards, data aggregation/warehousing/mining, and knowledge generation address preparation of practitioners for utilizing health data effectively.

Examples of How Data Usage Can Be Taught in Clinical Settings

Increasing the use of data in decision making and driving improvement in busy health care organizations is a challenge on many fronts. Patients are sicker, staff shortages exist in key markets such as nursing and pharmacy, and new regulatory requirements and technology seem to appear at every turn. Incorporating data in applications such as statistical process control via the use of control charts to identify outlier events is a useful strategy but needs to be easily incorporated into the busy clinical environment. Educating clinical leaders, including nursing managers and physicians, to create statistically correct control charts with a spreadsheet is not feasible due to the complexity of the analysis and the different computer skill levels of the managers. Purchasing specialized computer software is expensive and the software often has a long learning curve.

The preferred alternative approach is to simplify the process such that each manager only needs to enter data into a spreadsheet and click a few buttons to create the control chart. The primary educational focus is the use of customized spreadsheet menus which create the charts as well as interpret graphs and develop action plans to improve patient care and operations. The education process focuses on the mechanics of chart creation and then shifts to problem solving and root cause analysis techniques to address the identified issues.

Key elements of the informatics curriculum for public health and health care professions include data definitions, data management tools, data quality, and system selection. The following sections describe these topics in detail.

How Data Are Collected and Managed

Identification of Common Data Definitions Is Essential

It is very common for different individuals or departments to have different definitions of the same data element. Unless everyone is using the same set of data definitions from the beginning, there will likely be errors in data collection, analysis, and conclusions. For example, does the hospital admission date and time occur when the patient arrives at the emergency department or when they are admitted to an inpatient bed? Is the infection rate based on all patient days or only the days on which the patient has a catheter placed? Are children's ages stored in the database in months or years? Are names entered as "John Doe" or "Doe, John?" A lack of planning and agreement on basic information in any of these examples will result in confusion, rework, and lack of useful data.

In addition to agreement on the definition of each data element, the following aspects should be considered and documented:

- *Data elements*. Sufficient data are needed to avoid ambiguity in names. Admission date and inpatient admission date should be distinquished.
- *Description.* Brief but clear descriptions of complaint/treatment should be understandable by the nonexpert.
- *Numerator and denominator definitions for rates.*
- *Data storage format*. For example, options may include text, number, yes/no.
- *Units of measure*. For example, body temperature may be recorded in Celsius or Fahrenheit.
- *Default value*. To speed data entry time the most common. value for a data element might automatically appear.
- *Is the data element required?*

Tools for Managing Clinical Data

Desktop computers contain a variety of powerful desk tools for data management and analysis. Selecting the best tool or tools for each situation is a key element of the education program. Three common data management and analysis tools available to public health and health care students and professionals are spreadsheets (eg, Microsoft Excel), databases (eg, Microsoft Access), and statistical applications (eg, STATA, SAS).

Spreadsheets are the analytical computer programs with which most people are familiar. They are the easiest to learn and provide both data management and statistical tools and typically have a wide range of capabilities that enable them to be used in lieu of more complicated computer programs. Spreadsheets are relatively intuitive to use and learn, excel in graphically displaying data, provide a variety of statistical functions,

and can support up to millions of data values. On the downside, spreadsheets lack strong data validation tools which can lead to data quality issues when entering large amounts of data. The standard spreadsheet data format (2-dimensional table) is easy to create but is inefficient for complex data sets and often results in data redundancy. This redundancy wastes data entry time, increases file size unnecessarily, and creates more opportunities for data entry errors. Finally, spreadsheets can only be updated by one person at a time.

Database programs are less intuitive to learn and use. When properly designed, however, databases can provide very efficient data storage for complex data sets and eliminate the data redundancy inherent in spreadsheets. Databases also provide strong validation and entry tools that facilitate data entry and improve data quality. Database programs allow multiple users to add and update data simultaneously—a key feature for large scale data collection and sharing via a central data repository. Reports can be designed to quickly generate weekly or monthly reports without needing to cut and paste data as when using a spreadsheet. On the downside, databases tend to have fewer tools for statistical analysis or graphing capability as compared to spreadsheets.

Specialized statistical programs provide for extensive analyses of large data sets using a wide range of statistical functions. They provide graphing capability but typically not to the extent of spreadsheets. These statistical programs are the tools of choice when performing analyses for publication which are beyond the basic regression and t-test functions available in spreadsheets. However, these programs do not support the strong data validation, management, and reporting functions common to databases.

A key educational focus emphasizes the strengths and weaknesses of each tool and how to quickly move data between them in order to utilize the benefits of each application without being limited by a program's weaknesses. A typical example of using the programs together might be to use the database for data entry and validation, the statistical program for detailed statistical analysis, and the spreadsheet for graphing the results.

The Importance of Data Quality

No matter how well a spreadsheet or database is designed, it will not be able to serve its purpose if the data it contains are inaccurate or incomplete. Maintaining the quality of data in a spreadsheet or a database requires diligence, planning, and constant monitoring. Clinical managers must be taught to evaluate the quality of data prior to using the data to make decisions.

It is always faster and more efficient to prevent inaccuracies or incomplete data during the data entry process than it is to find and fix problems after the damage is done. Several strategies can improve the quality of data in a database. Proper design is the first step to preventing data quality problems. Most computer programs contain standard features to prevent data entry errors such as selecting the type of data that can be stored in a particular location. For example, if the database requires entry of a date in a certain location then the entry of an invalid date would be prevented. Assigning range limits prevents entry of invalid data while requiring the entry of a value prevents incomplete data. Required fields should be used carefully, however, as requiring the entry of too many values may introduce bad data if users become frustrated with a lengthy data entry process. Involving data entry personnel early in the development of a database improves the data entry process and tools and reduces the potential for errors.

Data users should understand how the data they are using are defined. This is particularly important if the data are being used secondarily, and it is not possible to influence how the data are entered. For example, there are two federal data standards for information regarding race (eg, American Indian or Alaskan, Asian or Pacific Islander, Black or White) and ethnicity (eg, Hispanic or Non-Hispanic).[17] However, many health care organizations collect only one combined field, and it is not possible to accurately determine the race or ethnicity of their patients.

If a spreadsheet or database contains bad data, auditing the data may be an option to identify or correct errors.[18] Range checks can identify values that are too large or too small, and sample calculations can identify invalid or missing entries. Although auditing will often find a majority of bad data present in a program, it is always better to prevent the bad data from being entered in the first place.

System Selection Issues

Clinicians and managers should participate in the selection of clinical information systems whenever possible, and they should be prepared to consider data needs during the selection process. This issue should be included in the curricula of health informatics programs; however, the focus of systems selection is often weighted heavily toward clinical issues. While issues such as user friendliness and integration with the clinical workflow are important considerations in the selection of clinical information systems, data management issues should also be kept in mind. The quality and availability of data for use on the back end is important in order to facilitate other uses of routinely collected health data such as benchmarking, quality improvement, research, and surveillance. Vendors should be questioned about the types of reports that are available from these systems as well as the option to customize reports, export data for use with other computer applications, or run ad hoc reports locally rather than having to request the data from the vendor.

As the health care informatics field has developed, there has been recognition of the need to prepare informatics experts in both the clinical and managerial ranks. There also is a need to educate nonmanagers in basic informatics content. Professional and educational organizations are working to address these needs through formal educational programs as well as the development of competencies and certifications. While the various educational programs, competencies, and certificates continue to be developed, it remains to be seen how widely adopted these initiatives are at present. Clinicians and managers

would be wise to take a proactive approach to acquiring health care informatics knowledge and skills in order to make the best use of data for direct care as well as in support of optimal health services organization and delivery, public health surveillance and practice, and clinical research. **NCMJ**

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