In search of dialogue and discourse in applied clinical informatics

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Summary

We present a model of applied clinical informatics in the context of medical informatics in general, across the domain of health sciences and the continuum of information technology development and its adoption into workflow. The distinct challenges of applied clinical informatics present an opportunity to improve efforts through collaboration of the growing number of physicians, health institutional leaders and other health workers in successfully implementing working systems. This journal will be a forum for discussion regarding approaches to design, implement, deploy and evaluate systems and importantly, how to present experiences in a way to maximize sharing of those experiences.

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Applied clinical informatics (ACI) is the science and art of applying and managing data and information technology to improve health processes and outcomes in medical care and disease prevention for individuals, groups and populations – in short: applied clinical informatics is a vehicle by which data and knowledge are translated and transformed into results and practice.

To develop useful dialogue and discourse within this domain among its many participants and stakeholders, it is helpful to define and characterize what we mean by the terms informatics and more specifically clinical informatics.

Informatics as human activity and process

Informatics is an iterative human activity that creates and develops relationships and interactions between a domain (such as clinical medicine) and intellectual models. Friedman describes this activity (biomedical informatics) in terms of four "acts" of a collaborative and creative "achievement" process:

- *Model formulation:* acquisition, representation, processing, display and/or transmission of biomedical information or knowledge
- *System development:* creation of innovative technologies that deliver information or knowledge to health care providers using formulated and emerging models
- *System installation:* assurance of reliable operation of developed systems within functioning health care environments
- *Study of effects:* examination of installed systems on the reasoning and behavior of health care providers and on the organization and delivery of health care [1].

These acts, originally described as a "tower" paradigm, may also be considered as an iterative model as shown in ▶Figure 1

As shown in Figure 1, Friedman's "acts" may also be mapped to familiar information technology development activities: analysis, design, implementation and evaluation respectively. Each "act" may bridge intellectual activities of discovery (finding problems and questions) and abstraction (creating theories and models), abstraction and operationalization (building designs, hypotheses, experiments, and prototypes), operationalization to realization (producing working systems, new facts and data) and realization back to discovery (finding new and unanticipated results, questions and problems based on new facts and data).

Foundational ("pure") and applied informatics and the health domain

Separating biomedical informatics into foundational ("pure" or "research") and applied branches is arbitrary and based largely on pragmatic and social aspects of the use of information technology (IT). Initially, when use of an IT application within a health domain is new, it is considered experimental (part of research) or part of specialized practice and responsibility is shared between health care innovators and IT experts. As the value of the application becomes accepted (through published research) among health care workers and availability increases (through demand or endorsement by professional medical organizations), it becomes an inherent part of practice to the point where is no longer new, but simply part of "doing business" in care. When the application has widespread adoption, it becomes subject to standardization by a combination of professional medical organizations, technical authorities and collaborative organizations to assure reliability.

This translation of informatics research into clinical practice thus comprises a continuum of IT development and healthcare problem solving (▶Table 1): from "pure" information technology to the health domain where:

- *Foundational informatics* is concerned with exploring a (health) domain, discovering its structures and processes and defining questions and problems for innovative solution based on findings and observations. Activities of foundational informatics include the development of models and knowledge representations of a domain that confirm and predict findings and observations.

- *Applied informatics* is concerned with solving specific problems within a (health) domain by applying formulated models to observed data. In contrast to foundational informatics, activities of applied informatics include the development of systems or applications that control or guide processes (in addition to confirming and predicting outcomes). Applied informatics also concerned with the new systems that are created when applications are incorporated into human workflow and the cognitive, communication and organizational impacts on human interactions of IT-enhanced information workflows.

From an informatics standpoint, the health care domain can be considered in terms of:
- *Basic science:* the study and understanding of the evidence bases of medical care.
- *Clinical practice:* the care of individuals patients based on evidence
- *Health services:* the management and delivery of care services for patient groups
- *Public health administration:* the surveillance and management of health for populations

Applied clinical informatics as an emerging field

Applied clinical informatics (▶Table 2) includes IT issues regarding patient care at the individual (patient-provider) level as well as health services delivery at the group level (patients, providers [such as hospitals, care units, care teams]). Applied clinical informatics is also intimately involved with the interface between data, knowledge and clinical work and as such, presents problems that are distinct from other areas of informatics:
- *Diversity of patient care, quality and safety:* Patient care depends on many factors: the patient, the illness, the provider, location, insurance status, the care process, the specific care environment (institution, leadership, teams, policies and procedures). Thus, a given application or system may produce different results (process failures, outcomes) in different clinical settings [3].
- *Multiplicity of workers in distributed care:* Providers in different roles have different perceptions of the totality of care for a patient. This may result in different interpretations of the same data with different results and may result in errors and/or unanticipated problems.
- *Variability in response of workers to non-standard situations:* Providers are focused on "getting the job done" and may resort to workarounds that use IT (and other technologies) in ways that were not intended and that may be harmful [4].
- *Complexity of impacts of errors on patient safety:* Many errors occur with little to no impact on patient safety. Some errors may be caught and corrected (and as such, go unreported) while other errors persist (as latent errors) [5] for long periods of time, only to present as a catastrophe. In addition, prevention of extremely rare errors may be technically and/or economically infeasible for institutions to prevent.

The analysis of clinical workflows and the design, implementation, deployment and evaluation of the new systems that result from health IT adoption is challenging and essential. While informatics research provides guides to these activities, each system (clinical environment, patient population, organization, care team) is unique and "one size" or "one application" rarely fits all. Therefore, helpers with expertise (applied informaticians with clinical backgrounds) and shared experience in getting applications to work effectively in clinical environments are needed.

Sharing and reporting applied clinical informatics expertise and experience

It is necessary and helpful to provide guidance for researchers and workers in applied clinical informatics to publish results in forms useful to those who are implementing similar systems within their own clinical environments. In many cases, implementation efforts are based only on knowledge derived from informal communications and collaborations among like institutions, site visits and local planning. To disseminate and share successful strategies, it is necessary to have a frame-

work on which the diverse and detailed information needs of implementation teams can be met. Such a framework (or frameworks) must include standard ways to report:

- *Descriptions of institutional and care unit structures and processes:* In addition to methods to classify and describe leadership and organizational structures, including economic and political motivations, ways to describe all stakeholder groups from patients to board members are needed as are ways to describe or measure workplace culture (in health settings, quantitative measures of safety culture and change over time have been described [6]). Since most of the direct effects of interventions (such as the adoption and implementation of health IT) and errors occur at the care unit level (the front-line areas where patients receive care), methods of socio-technical description of specific clinical environments which include how communication occurs (and does not occur) are needed [7, 8].
- *Evaluations of applications and systems:* Evaluations of IT systems must go beyond basic descriptions of functionality and general performance metrics that show applications under optimum circumstances. There needs to be inclusion of how specific clinical environments and workflows in which specific systems are deployed provide opportunities, constraints, affordances and/or barriers to implementation, deployment and evaluation. One methodology for informatics interventions has been described, which provides a standard format for reporting evaluations in a comprehensive fashion [9], while another suggests that a collection of smaller scale evaluations may be more informative than a large one [10]. Both may be useful in providing a comprehensive picture of a given system.

The goal of this or any approach to standardized reporting must be to accumulate reliable data and evidence that is comparable, useful and usable for institutions to base their own efforts. Clearly, there are hurdles to overcome to make this a reality: from IT vendors in sharing information about their proprietary products and from health practices and institutions unable or reluctant to share information on health IT implementation failures, especially those that have led to patient harm.

The journey of applied clinical informatics begins with a single step. In order to translate health IT knowledge into widespread adoption of reliable clinical systems that help provide safe and effective care for all patients, we must learn to share experiences and expertise in applied clinical informatics in a meaningful fashion. We invite dialogue with the informatics community on building this framework.

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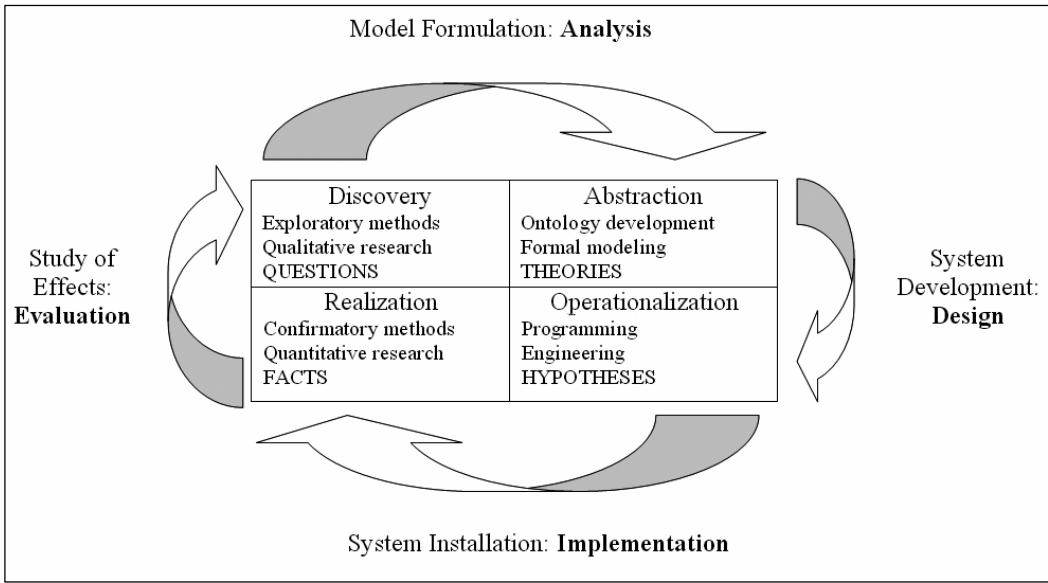
Model Formulation: **Analysis**

Study of
Effects:
Evaluation

Discovery
Exploratory methods
Qualitative research
QUESTIONS

Abstraction
Ontology development
Formal modeling
THEORIES

Realization
Confirmatory methods
Quantitative research
FACTS

Operationalization
Programming
Engineering
HYPOTHESES

System
Development:
Design

System Installation: **Implementation**

Fig. 1 Informatics as a collaborative and iterative intellectual activity

Table 1 The spectrum of health and informatics in the case of genomic tools

Health domain	Conducting genetics research
Applied Informatics	Developing genetic testing methods
Foundational Informatics	Modeling screening: microarrays
Information technology	Building data mining tools: chips

Table 2 The place of applied clinical informatics in the health and informatics continuum

Basic science	Clinical practice	Health service	Public health
Domain use of Information and Communication Technology (ICT)			
General and standard use of functional, network and enterprise tools [2] in work			
E-mail Digital libraries Research databases	Cell phones EHRs/PHRs Health Information Exchange	Scheduling tools Paging systems Billing systems	Decision tools Broadcasting Surveillance
Applied informatics			
Investigative and developmental use of ICT to improve work			
Using models to confirm and predict: • Select drugs for study using microarray data • Can microarray data save money on research and development?	Using informatics to improve care: • Test digital libraries in physicians' offices • Why does providing access to information at the point of care NOT improve physician performance?	Using informatics and IT to optimize system response: • Provide automated alerts to clinicians for panic laboratory values • Do just-in-time automated alerts improve clinician response or quality of care?	Impacting population health via surveillance: • Measure emergency department chief complaints to predict community influenza onset • Can knowledge of "first events" help reduce morbidity and mortality?
Foundational informatics			
Inference and deduction of models from domain data			
Discovering and modeling biological structures and processes: • Development of genomic and anatomic semantic models and terminologies • How well do such knowledge representations accurately model reality?	Defining and abstracting clinical entities and relationships for common use: • Determining strength and specificity of findings to specific diseases • How well do findings or constellations of findings predict presence of disease?	Modeling clinical information workflows and processes for analysis: • Simulating a care process such as resuscitation • What are the important communication links during acute patient care scenarios?	Finding and defining patterns and relationships in health behaviors, processes and outcomes: • Measuring cigarette purchase within a population and measuring lung disease • What are health determinants and how are they measured?
Pure IT development			
Design and implementation of hardware and software			