

Context Sensitive Health Informatics: Delivering 21st Century Healthcare - Building a Quality-and-Efficiency Driven System

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Abstract. Health informatics applications will be a cornerstone in the next generation quality-and-efficiency health care system. Health care is delivered from many different specialties, to many different patients with complex diseases and comorbidity. A one size fits all approach is not adequate to reach the Triple Aim of improving the patient experience of care, improving the health of populations, and reducing the per capita cost of health care. Health informatics applications must be built to be adaptable and sensitive to the complex contexts they will be used in. To enhance patient-centeredness in the 21st Century healthcare, research attention should be focused on investigating and designing models contributing to effective health information retrieval process.

Keywords. Context, health informatics, 21st Century healthcare, information retrieval

Introduction

Healthcare delivery is a complex system involving different delivery models, costly resources and interventions, and requiring contributions from multiple actors including highly skilled healthcare professionals, and patients, insurers and administrators. An aging population and need to provide care for complex patient cases (e.g. chronic disease management) has led to growing global demands for increased delivery and better cost efficiency of healthcare services. In this information age, it has been argued that many of the solutions we seek may be found from health informatics methods and tools [17; 22]. Yet, health information systems (HISs) differ from traditional business enterprise systems that usually possess well-defined concepts, workflow and structure, for example, IT design for the banking industry [14]. The healthcare system must be understood as a complex system because of the multitude of convoluted concepts and intricate relationships within it [15]. Complexity makes the design and implementation

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of informatics solutions challenging [18]. A particular complexity challenge is developing informatics solutions that support multiple health system objectives such as patient centered care, safe and efficient care, and the provision of high-quality services at an affordable cost.

Value for the patient has been described as an overarching model by which healthcare reform should be designed around [25]. Yet, patient centeredness has not been a mainstream element in healthcare service delivery in the past. Care delivery has been passive in a way that most of the time patients do not have enough awareness about their health conditions and control over treatments. A challenge for medical informatics researchers are to design tools to better support patient-centered practices. On one hand, automation has radically changed consumers' lives in the 21st Century. Transportation services (e.g. Uber), entertainment (e.g. streaming music apps), travel (e.g. self-booking tools such as Expedia) and financial management (e.g. financial trading and investing services such as E*Trade) all empower consumers in unprecedented ways. Yet, when we talk about the upmost important issue – one person's health – people are often reduced to passive recipients. Engineering a quality-and-efficiency driven healthcare delivery system that puts patient centered care at the forefront is an important endeavor that requires innovative research efforts. In this theme paper, we outline health informatics research challenges, provide examples of state-of-the-art research, and describe potential research directions in pursuit of a patient centered healthcare system.

1. The Visions of 21st Century Healthcare

Institute of Medicine (IOM) describes patient-centeredness as one of the core healthcare services deliverables [1]. Patient empowerment, which refers to effective management of health care decisions and execution by patients as well as their families, has been packaged as one of the several key competences in the 21st Century healthcare [1]. To achieve the competence in this information age, we envision a solution driven by *information-intensive* advantage gained in health (via effective use of data to make efficient and intellectual decisions).

Since the early 2000s, the amount of data has been growing rapidly in the world and the majority of our technological memory has been digitally archived, awaiting further potential applications. The Data-Information-Knowledge-Wisdom (DIKW) pyramid [14; 26] (also called DIKW hierarchy, or information hierarchy) refers to a class of models for representing the structural and functional relationships between data, information, knowledge, and wisdom. Big data is potentially making huge impacts on businesses, finance, retail, manufacturing, as well as population health [27]. However, unlike other business fields which have a very narrow semantic gap between data and information [14], the correspondence between data and information in health is indirect. It has been difficult to contextualize health and human experience objectively [19].

Information retrieval is defined as “finding material of an unstructured nature that satisfies an information need by retrieving documents from large collections” [14]. It concerns with retrieval of information sensitive to context instead of retrieval of data. Typical computer science and data analytics methods are designed for data extraction, analysis and processing using algorithms implemented to carry out data retrieval tasks efficiently [28]. For example, queries and optimization algorithms allow us to search peaks of seasonal influenza epidemics from massive databases [23], however such

search methods cannot accommodate higher level disease epidemiology questions, for instance, to understand the difference in disease epidemiology from two virus strains [6] and from heterogeneous patient groups [2]. Current searching methods allow us to look for a large number of documents relevant to specified keywords from medical databases [5], however, the document search results often exhibits high type I error due to a large number of false-positives that are usually included [14]. Information retrieval processes frequently require manual intervention and judgement to determine its relevance [9], and is also highly disease and context specific, which makes it challenging to tailor treatment solutions to improve individual patient experiences and to satisfy individual patient needs.

The challenge health informatics research faces in developing patient centered solutions is that that healthcare delivery is ultimately about people and we cannot consider technology alone but rather need to use a *sociotechnical approach* [3; 8; 17; 22]. To that end, health informatics is a cross-disciplinary science that combines and integrates expertise in several fields including human factors, computer science, data mining and machine learning, organizational behavior, psychology, operational research, and information science, among others. A key message from sociotechnical approaches to healthcare delivery is that a one-size-fits-all approach is not adequate. Reaching multi-level objectives such as the Triple Aim of improving the patient experience of care, improving the health of populations, and reducing the per capita cost of health care [4] will require inter-disciplinary approaches.

2. Towards 21st Century Healthcare: Research Efforts in Building a Quality-and-Efficiency Driven System

We envision one day we can learn from aggregated clinical data to tailor-make patient-centered treatment decisions efficiently. A question like “what were the clinical outcomes of patients like me (with the same demographic and disease complications) who chose treatment A instead of treatment B?” can be answered instantly at the point of care (that refers to computer-aided decisions are found during the care of patients [11]). Raw materials required to answer this question in fact may exist in massive hospitals historical patients’ clinical records, however, to effectively converting data to information and produce meaningful clinical implications has yet to achieve.

Research studies are currently moving towards the above directions. For instance, University Grant Committee (UGC) (Hong Kong) recently funded a Theme-based Research Scheme (TBS) to answer challenging questions in delivery a 21th century quality and efficiency driven healthcare in order to achieve “*better care at affordable cost, for a healthier life*” [7], particularly focusing on aging population and enhancing elderly care health services experience. Patient safety informatics studies, such as, [16] attempted to automate unstructured clinical notes to analyzable format [24; 30] and to automate medical incidents reports classification. In terms of consumer health informatics direction, randomized control trial was used to evaluate the outcome of consumer health platform [20]. Technology induced errors have been topical. Several studies focused on barriers, facilitators [10], as well as of outcomes from health information exchange [13]. Machine learning and artificial intelligence methods, such as topic models [29] and deep neural networks, are also increasingly applied into big healthcare data to improve health information retrieval processes. Other pioneer operation research employed cross-disciplinary optimization theories and methods to

optimize clinical flow and timetabling [21], demand prediction [31], and handle data bias issues [12].

Context Sensitive Health Informatics (CSHI) 2017 continues the work started in previous CSHI conferences in Copenhagen, Denmark (2013) and Curitiba, Brazil (2015). CSHI 2017 called for papers presenting research that provide insight on contextual aspects of healthcare delivery and approaches for innovative design for managing healthcare complexity. CSHI 2017 encouraged submissions from a range of themes including:

- Redesigning healthcare work
- Patient participation in care design and redesign
- Human factors and usability
- Theoretical approaches to investigate context sensitive health informatics that will generate robust evidence

3. Conclusion

Health care systems should be a well-organized structure that entails both healthcare providers and patients to “do the right thing”, “at the right time”, “in the right place”, and “in the right way”. Health informatics applications is a cornerstone in the next generation health care system, that contribute to quality and efficiency in health care delivery. Health care is delivered from many different specialties, to many different patients with complex diseases and comorbidity. A one-size-fits-all approach is not adequate to reach the Triple Aim of improving the patient experience of care, improving the health of populations, and reducing the per capita cost of health care [4]. Health informatics applications must be built to be adaptable and sensitive to the complex contexts they will be used in.

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