Chapter 6.6
Systems Engineering and Health Informatics:
Context, Content, and Implementation

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ABSTRACT

Healthcare organizations are struggling to provide safe and high quality care while reducing costs. Abundant data on various aspects of the care delivery process (both clinical and non-clinical) are collected and stored in large databases in different parts of the organization. Informatics, as an area of study with roots in computer science and information science, has grown and evolved to enable collection, storage, retrieval, and analysis of data, and reporting of useful information. Health informatics (HI) ranges from bioinformatics to public health informatics depending on the level of focus and applications. At the same time, systems engineering (SE), as an interdisciplinary field of engineering, has grown to encompass the design, analysis, and management of complex health systems to improve their quality and performance. HI and SE are complementary in their approach to identification of problems, methodology, and solution procedure for improvement. This combination brings forth implications for industry and education to address pressing issues of today's health care delivery.

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INTRODUCTION

With advances in clinical sciences and medical technology, people are living longer and there is a greater demand for healthcare services. The Institute of Medicine's report *To Err is Human* (Kohn et al., 2000) describes serious concerns in health care owing to undesirable outcomes related to safety and quality issues. These issues have been attributed to breakdowns in processes embedded in the service delivery structure (Institute of Medicine, 2001). Healthcare delivery systems have two major goals – *doing things right* and *doing the right things*. These are known as *efficiency* and *effectiveness,* respectively, in systems theory. With rising costs, efficiency is an important goal for all systems, including health care and this can be ensured through proper allocation of resources. Effectiveness and obtaining the desired outcomes, on the other hand, is all the more important in health care, considering the dire consequences of errors and process breakdowns that may lead to harm and even death. Yet, healthcare organizations are struggling to provide safe and high quality care, while reducing costs. Healthcare expenditure has been on the rise, for example, the United States spent nearly two trillion dollars in 2005. This amount accounted for 16% of its GDP, a proportion which is higher than any other country in the world (England, 2007; OECD, 2009). Hence, healthcare providers, insurance companies, and health care policymakers are striving to find more cost-effective methods to deliver health care. Providers are increasingly looking at methods that would help them reduce costs without compromising on the quality of care.

The Institute of Medicine (IOM) identified a four-level, patient-centered conceptual model as the unifying framework and guiding principle for redesigning and improving the healthcare system, to achieve better performance goals (Reid et al., 2005, p. 20). This IOM report proposes using information technology and systems-engineering tools to provide safe and high quality care that is efficient, effective, and patient-centered.

In today's healthcare organization, data is collected every day and stored in large databases. Intuitively, when data are abundant and no other sources of expert knowledge exist, one could expect that knowledge could be gathered from the data that are available. Informatics is the science of collecting, storing, retrieving, analyzing, and reporting information acquired from health data (Coiera, 2003; Protti, 1995). Given the abundant information on clinical, financial, human resources, care delivery, quality, patient satisfaction and outcomes, data mining tools are needed for decision-making. These tools extract hidden information from large databases so that organizations are able to identify important patterns, predict future behaviors, and make proactive, knowledge-driven decisions (Medina-Borja & Pasupathy, 2007). Such decisions (both clinical and managerial) will not be effective, unless they are based on true representations of processes that transcend any of the individual areas above, within a health system (e.g. clinical, financial). If no one within the organization has a holistic understanding of the system, finding an expert who will clarify the relationships or finding enough organizational documentation to point in the right direction is a challenging task. To be able to have a holistic representation of the processes within a hospital, an understanding of the broader systems, including the clinical system, hospital organizational system, etc. is necessary. Further, how can the relationships "mined" and the resulting patterns be validated against the real-world behavior of health systems? Several systems engineering tools classified under system-design, system-analysis, and system-control tools can come to the rescue. These are proposed by the Institute of Medicine report in 2005 under the umbrella of systems engineering (Reid et al., 2005).

The goal of this chapter is to accomplish the following,

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