A Systems Approach to Predicting Healthcare Failures

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Abstract

Adverse events and hospital-acquired infections are a costly and unnecessary part of the healthcare delivery system. While many factors are attributable to these errors, two-thirds of sentinel events that contribute to medical error in hospitals are due to breakdowns in communication. While there is an ever-increasing amount of digital communication devices (such as physician warning systems and electronic health records), these devices are applied on top of a complex foundational layer of analog human-to-human communication channels. By analyzing this foundational layer as a communication system where the stakeholders comprise the components and their interrelations comprise the interfaces, the authors believe the strengths and weaknesses of the system can be characterized and leveraged to predict communication breakdowns that could lead to suboptimal, or even harmful, "care" delivery. Towards that end, this paper will further characterize the contributing factors of sentinel healthcare events and define the stakeholder communications system in the healthcare delivery environment. Then, the authors will discuss the advantages of applying geographic information systems tools and technology to map stakeholder communication systems and applying terms and formulas from the field of social network

analysis to characterize the strengths and weaknesses of those systems.

Author Keywords

Complex Systems; Data Analytics; Geographic Information Systems; Healthcare; Social Network Analysis; Stakeholder System

Introduction

Adverse events and hospital-acquired infections (HAIs) are a costly and unnecessary part of our healthcare delivery system today. A 2013 estimate suggests that up to $10 billion is spent in the United States on HAIs, excluding settlements and malpractice coverage [24]. While many factors are attributable to these errors, two-thirds of preventable events that contribute to medical error in hospitals can be attributed to breakdowns in communication [18].

In today's technology-dependent healthcare delivery system, many people equate communication systems to an array of Information Technology (IT) tools including physician warning systems and electronic health records. While electronic health records and other IT tools have helped to mitigate potential communication breakdowns, evidence suggests that they are effective in concert with strong interpersonal communication and cannot alone replace the value of person-to-person communication. If strong interpersonal communication exists, IT is likely to have more success; thus by deduction, the lack of it can be significantly detrimental [8].

With these aspects in mind, it is seemingly critical to understand the full spectrum that defines the patient-encounter. Towards this end, we propose viewing healthcare stakeholders and their interrelations as a communications system where the stakeholders are the components and their interrelations are the interfaces. In this paper we further describe the healthcare stakeholder communication breakdowns and their harmful effects. We also define the foundational healthcare stakeholders communication system. Next, we discuss how Geographic Information Systems (GIS) tools and techniques can be used to capture the dynamic structure of the stakeholder communication system and how Social Network Analysis (SNA) terms and standardized formulas can characterize the strengths and weakness inherent to the communication system. As a result, we hope that further research will identify system conditions and/or behaviors that are mostly likely to lead to suboptimal, or even harmful, "care" delivery.

Contributing Factors to Adverse Medical Events

Communication is often taken for granted in our present technology-dependent healthcare delivery system. What we find to be an important facilitator to patient-provider encounters and improved outcomes, is also becoming critical for the success of IT and patient safety initiatives. While patient-provider communication has been widely studied and benefits clarified, what is not as well understood is the role of peripheral encounters, defined as the communication and interaction of clinical and non-clinical staff. It is the role of these stakeholders and their behavior in these peripheral encounters that contribute to our fragmented health encounters. These stakeholders can be considered anyone in the location of care or related to the delivery of care. They can include allied health staff, administrative staff, leadership, clinicians, nurses,

or any other personnel employed by a hospital-organization.

The literature supports the important role of strong interpersonal communications. A 2013 study reported that organizational support for interpersonal communication and interaction played a role in reducing sentinel events. Sentinel events can be described as preventable, unexpected adverse events [6]. Improved patient safety was also attributed to leadership, communication and interaction between management and clinical staff [2]. Chang (2012) found that improvements in communication between administrative leadership and staff increased knowledge sharing within units and between staff which also contributed to unit patient safety [5].

What is lacking in the literature is a greater understanding of the interaction between every person in the care encounter, including clinical providers, administrative, non-clinical leadership and staff and their role in the care encounter. Understanding these factors and the role of interaction at all levels of the hospital-organization may not only contribute to improved patient safety but also to better alignment of organizational processes by detecting patterns in communication networks [15].

Potential Frameworks and Guiding Perspectives

Health services do not follow standard organizational structural hierarchies. In order to contextualize and better address the complexity of the organization and delivery of care, alternative perspectives must be considered to address what is known as the quality conundrum. This conundrum implies we do not enjoy the level of quality (output) we should expect given the larger proportion of funds we spend (input) on healthcare. In this research we apply this thinking to understanding the nature and formation of networks that are activated in non-linear patterns in response to patient dynamics. Given the importance of appropriate handoffs and growing complexity of care today, the need for a faster and more efficient method of measurement can drastically improve our understanding of actionable factors.

Conceptually, a systems perspective to assess the organization and quality of healthcare delivery can be drawn from multiple frameworks including Complex Adaptive Systems and Donabedian's Model for Quality of Care among others [3, 7, 9, 12]. Complex adaptive systems theory suggests the relationship between input and output may be non-linear, which supports a common given in healthcare regarding the quality conundrum facing our fragmented healthcare delivery system. Donabedian's framework suggests quality of care can be assessed at multiple levels including structure, process, and outcome. The combination of these perspectives can provide a framework for visualizing the organization of not only the delivery of care but also the people involved in delivering this care in a safe, timely, and patient-centered fashion in support of the triple aim [4].

These efforts can also be achieved through the perspective of the Healthcare Stakeholder Communication System. As defined by Wood et al. the stakeholder system is a system in which the stakeholders are the components and their interrelations form the n*(n-1)/2 interfaces where n equals the number of stakeholders [20]. While Wood

and his colleagues' original example involves stakeholders in a defense program, the stakeholder system concept is equally valid in other industries and domains including healthcare. Within the process of delivering care there are a plethora of active stakeholders. As mentioned above, these actors or staff, can be considered anyone in the location of care or related to the delivery of care. They can include allied health staff, administrative staff, leadership, clinicians, nurses, or any other personnel employed by a hospital-organization.

As is the case in many systems engineering projects, special attention is needed at the interfaces of the communication system as that is where systematic breakdowns are likely to occur. Likewise, the authors of this paper suspect that systematic breakdowns in the healthcare workers' communications directly equate to breakdowns in the stakeholder system. The challenge then lies in defining the characteristics of this communication system, because unlike engineered communication systems, these parameters are not designed but rather *emerge*. Given this emergent nature, we need to engage science to first map and then characterize the stakeholder communications system. To do that, the authors propose employing GIS tools along with SNA terms and standardized formulas.

Potential use of Geographic Information Systems

Healthcare organizations and systems are busy, complex, multi-dimensional and occasionally chaotic. They remain under constant demand from policy makers, health care analysts, and funders to deliver the best possible health care that is also operative and cost-efficient [13]. In such a complex environment, evaluating individual interaction and communication structure is a non-trivial task, and the qualitative survey-based approach is a relative baseline step that makes scaling up cost-prohibitive, not to mention its potential to interrupt the active processes of delivering care. An approach leveraging location aware GIS technologies, on the other hand, has an advantage to investigate individual interaction and communication structure for a large-scale of study in a cost-effective and non-invasive manner.

Location-aware devices and related mobile technologies have enabled the recording of personal whereabouts at higher sampling frequency and location accuracy in indoor and outdoor environments. These temporal sequences of personal locations provide unprecedented opportunities to map patterns of human behavior through space-time analytics [23]. At a disaggregated level, patterns reveal the activities and locations as well as the development of routines for individuals, whereas at an aggregate level, patterns suggest collective activities, potential social networks, and social hot spots for interactions [16, 22, 23].

Potential use of Social Network Analysis

The SNA body of knowledge provides helpful tools and standardized measures that facilitate the characterization of complex groups including hospital organizations [14]. Their interaction is called a network because they are connected interdependently with differing levels of interaction and activity that result in varying degrees of communication which can translate to varying degrees of information quality and knowledge transfer. For example, SNA can help characterize and understand how information and knowledge flow in different health organization groups

such as operating room staff [1], clinical teams [17], and multiple divisions [21]. SNA facilitates this by quantitatively examining network properties including density, centrality, degree of connection, isolation, reciprocity, and transitivity [19]. Identified network characteristics can be further used to discover the role of the leadership in clinical teams [17], study the effect of peripatetic healthcare workers on the spread of hospital-associated infections [10], and examine the relationship between social network and coordination performance [11].

Conclusion

A systems perspective can play a critical role in the prevention, or promulgation, of adverse events and HAIs. Mapping and characterizing these systems has historically been a challenge due to the emergent nature of the system and the complex and demanding environment in which it exists. As new research tools become available, it is increasingly likely that this challenge can be overcome. We believe that time is now. By leveraging GIS tools and techniques, we can capture the dynamic structure of the critical communication system that is patient care. Then, by applying SNA terms and standardized formulas, we can characterize the strengths and weaknesses inherent to this communication system. Once several systems are mapped and characterized, we hope that trends will emerge and reveal the system conditions and/or behaviors that are mostly likely to lead to suboptimal, or even harmful, "care" delivery. Once identified, steps can be taken to modify the context, organization, and delivery of care to mitigate the risk of adverse events or the acquisition of HAIs and improve the overall patient experience.

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