Signaling Sepsis: Novel Data Collection of Diagnostic Mental Models

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Introduction

A patient arrives in the Emergency Department and then there is questioning, tests are ordered, and a diagnosis is established; a treatment plan is set in place and upon following medical recommendations, the patient's condition improves. That is a common, albeit ideal, course of events. In healthcare, however, this process is complex and requires knowledge of the evidence-base, human cognition, pattern matching, and clinical reasoning. Diagnosis has important implications for patient care, research, and policy.

Diagnosis has been described as both a process and a classification scheme, or a "pre-existing set of categories agreed upon by the medical profession to designate a specific condition". When a diagnosis is accurate and made in a timely manner, a patient has the best opportunity for a positive health outcome because clinical decision making will be tailored to a correct understanding of the patient's health problem. Little is known about how evidence-based knowledge is integrated into clinician metal models that often underlie human decision-making. A fuzzy cognitive map is a cognitive map within which the relations between the elements (e.g. concepts, events, project resources) of a "mental landscape" can be used to compute the "strength of impact" of these elements. Fuzzy-logic cognitive mapping has potential to measure and assess perceptions of sepsis diagnosis both individually and collectively. Taking a human systems engineering approach, the objective of this demonstration is to present a novel data collection tool, leveraging visual analytics as a means to knowledge discovery.

Clinical Context

Sepsis, currently defined conceptually as an infection with associated acute organ system dysfunction, is a common principal reason for hospitalization as well as the single most expensive condition treated in U.S. hospitals.[1] Even though this deadly disease accounts for nearly half of all hospital death[2], there is currently no gold standard diagnostic test for sepsis, making clinical diagnosis and treatment difficult. Over the past decade, medical guidelines related to sepsis are constantly evolving as the clinical community searches for consensus on the definition, diagnostic criteria, and treatment recommendations pertaining to the disease.[3] Challenges to detection and diagnosis are exacerbated by an extremely complex cascade of events. Due to difficulty of sepsis diagnosis upon presentation, clinicians critically evaluate information and use pattern recognition to reduce uncertainty enough to make optimal decisions for clinical care — but the pathway through diagnostic evaluation is subjective.

Methods

Cognitive maps were first described in 1976 as decision support tools, serving as visual representation schemes with a computational framework.[4] These maps illustrate knowledge as a network of concepts and their casual relationships. Fuzzy cognitive maps are cognitive maps in within which the relations between elements of a "mental landscape" imitate the way of decision making in humans and resembling human reasoning[5], providing greater utility of the model. These maps provide inexact (fuzzy) linguistic expression of concepts and causal links and allow for comparisons between individuals. We created a web-based application to capture clinician mental models by dragging and dropping words onto a target word, indicating the relationship between two words and thus creating a

mental model of diagnosis. Clinicians with experience diagnosing or treating sepsis are asked to participate in a web-based bull's-eye application with the word "sepsis" placed in the middle. Participants will place the list of sepsis-related words displayed on the left into one of 6 rings to illustrate how closely related each word is to the center word, "sepsis". The application quantifies the relationship by assigning value to the words based on ring selection. Data captured by our application is used to create individual and aggregate mental models. Analysis reveals trends in occupational, experience, and expertise variance. Addressing variability in terminology and preconceived ideas about sepsis diagnosis will lead to important advances for an early diagnosis and appropriate management useful to improve patient care.

Results

Qualitative static models were translated into semi-quantitative dynamic models. Analysis of clinician responses indicated that there was wide variability in clinicians' mental models for sepsis diagnosis but revealed similar themes once responses were organized in a structured terminology platform. Findings also indicated that clinicians identified as "experts" exhibited a clear, focused shared mental model. Mental models influence how clinicians' behave because models affect what people perceive as reality and can be used to connect values and beliefs that drive organization culture to a commitment to clinical care goals. A sepsis diagnosis decision support system that is developed to match either individual clinician mental models or shared mental models, at least in vocabulary, could produce a positive impact on system utilization and implementation.
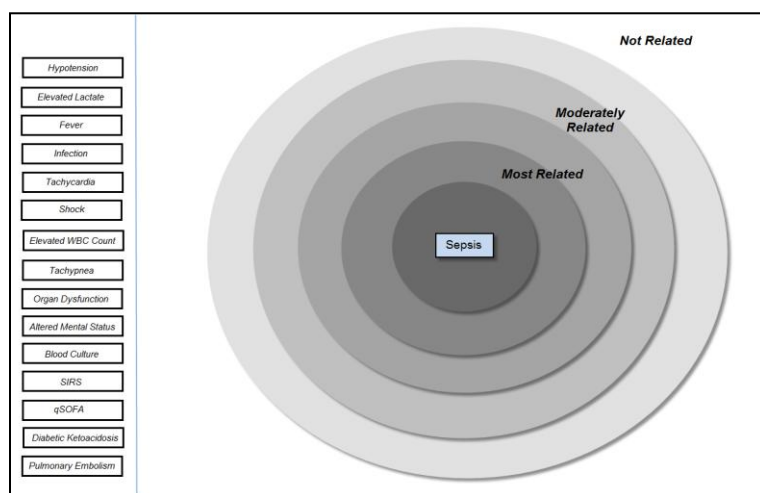

Figure 1. Mental modeler web-based application.

Conclusion

We have developed the sepsis mental modeler but the architecture allows researchers to utilize the application for any diagnostic process. We have replicated the model for other healthcare challenges including spinal cord compression diagnosis and priorities in health information technology architecture. We plan to make the tool publicly available. Our demonstration will include information about the technical build, word selection, results display, and analytic capacity.

References

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