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Identifying complexity in infectious diseases inpatient settings: An observation study

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ABSTRACT

Background: Understanding complexity in healthcare has the potential to reduce decision and treatment uncertainty. Therefore, identifying both patient and task complexity may offer better task allocation and design recommendation for next-generation health information technology system design.
Objective: To identify specific complexity-contributing factors in the infectious disease domain and the relationship with the complexity perceived by clinicians.
Method: We observed and audio recorded clinical rounds of three infectious disease teams. Thirty cases were observed for a period of four consecutive days. Transcripts were coded based on clinical complexity-contributing factors from the clinical complexity model. Ratings of complexity on day 1 for each case were collected. We then used statistical methods to identify complexity-contributing factors in relationship to perceived complexity of clinicians.
Results: A factor analysis (principal component extraction with varimax rotation) of specific items revealed three factors (eigenvalues > 2.0) explaining 47% of total variance, namely task interaction and goals (10 items, 26%, Cronbach's Alpha = 0.87), urgency and acuity (6 items, 11%, Cronbach's Alpha = 0.67), and psychosocial behavior (4 items, 10%, Cronbach's alpha = 0.55). A linear regression analysis showed no statistically significant association between complexity perceived by the physicians and objective complexity, which was measured from coded transcripts by three clinicians (Multiple R-squared = 0.13, p = 0.61). There were no physician effects on the rating of perceived complexity.
Conclusion: Task complexity contributes significantly to overall complexity in the infectious diseases domain. The different complexity-contributing factors found in this study can guide health information technology system designers and researchers for intuitive design. Thus, decision support tools can help reduce the specific complexity-contributing factors. Future studies aimed at understanding clinical domain-specific complexity-contributing factors can ultimately improve task allocation and design for intuitive clinical reasoning.

1. Introduction

The characteristics of infectious diseases (ID) set this domain apart from other areas of clinical care due to its complexity, unpredictability, and potential for global effects [1–4]. The complexity surrounding newly emerging infections, environmentally persistent organisms, and increasing antibiotic resistance interacts with patient acuity to create a significant decision-making burden [4,5]. Understanding the scope of factors contributing to complexity would help improve the design of clinical decision support systems, electronic health record (EHR) systems, educational interventions, and risk assessment. In the following background section, we discuss the importance to understand complexity in medicine.

1.1. Background

Complexity refers to the amount of information needed to describe a phenomenon or observation under analysis. The more

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disordered the phenomenon, the more data are needed until the phenomenon can be described in comprehensible terms [6]. Something is complex when it contains a large amount of important information that surpasses our ability to process it. The degree to which we can process information is a function of expertise and experience [7]. Experts can process a great deal of information if it is consistent with their underlying understanding. However, if something contains a large amount of useless and meaningless information, our minds have to expend a great deal of effort or we simply ignore the information.

Each domain in medicine deals with complexity in patient cases differently. Thus, the decision-making process cannot be generalized for all areas of medicine. In medicine, the complexity in family medicine may explain the high intraphysician variability in patient management that is observed for general practitioners. Therefore, physicians adjust the care they provide based on the complexity of the clinical situation or case [8]. Kannapalli and Patel studied different complex systems by conducting a functional decomposition of a complex system as a whole [9]. The degree of interrelatedness between system components was an indicator of system complexity. However, we are dealing with the provider, the patient and their context more from the psychological point of view. From this perspective, it is important to focus in on specific clinical domains.

Currently, there are few methods for estimating complexity in either ambulatory or specialty medical care. One study tried to define complexity from the perspective of "complexity theory." Complexity theory deals with the interplay of individual elements that results in systems with complex behavior. The different systems and their interactions give rise to the overall complexity. However, the framework of this theory does not take into account different characteristics of patient complexity [10]. This study included some related measures of risk adjustment, such as case-mix measures, that are used to compare patients seen by primary care physicians and patients seen by specialty services. However, the study did not capture the dimensions of health status, demographics, health behavior, psychosocial issues or cultural background. Another system, called ambulatory diagnostic groups (ADGs), uses a prediction system based on 51 ambulatory care groups and combined patients' age and sex to create a risk score mechanism [11]. Another similar approach, Ambulatory Severity Index (ASI), combines biophysical and behavioural dimensions with a complexity severity index [12]. This index also includes complexity based on urgency, complications, and communication. Other systems, such as the diagnostic-related groups (DRGs) and case mix groups (CMGs), are based solely on medical diagnoses [13]. However, these systems include too many patient groups, and their predictive power is limited. Their usefulness in defining case complexity is limited by the large differences within the diagnosis-based groups. The same DRG and CMG group developed a Complexity Prediction Instrument (COMPRI) using 117 items, including patient's admission status, severity of illness ratings, living/working situation, stress, social support, activities of daily living, health status, previous healthcare use, compliance, drug abuse, and emotional status [14]. Another group of researchers developed a new method for estimating the relative complexity of clinical encounters based on the care provided weighted by diversity and variability [15]. These methods have focused on risk assessment and assigning a value of severity. However, the specific contextual factors for each disease state are different due to the nature of the disease state and the complex attributes of specific patient cases. The different risk assessment parameters from the different research groups have not taken into consideration the perceived or subjective complexity of the task performer. Understanding the factors that may be influenced by perceived complexity can provide better understanding of the objective properties of such parameters.

Physicians and nurses define complexity in patient cases from various perspectives, including task complexity as well as patient complexity. Task complexity has been well defined in other successful areas of system design, including the defense industry, the humanities, engineering, business, and the social sciences. Several studies have found task complexity to be a crucial component of the environment that influences and predicts human behavior and performance [16–21]. Task complexity can be better understood by parsing it into objective task complexity and perceived task complexity. Objective task complexity refers to the characteristics of the task model [22]. In other words, it is the manipulation and quantitative assessment of task complexity based on the task model. It is the inherent complexity that exists regardless of the task performer's perceived notion of the level of complexity. Perceived task complexity considers the task performer's characteristics and the perceived difficulties of performing the task [23]. Subjective task complexity is the complexity of the 'state of mind' of the individual who performs the task. Thus, subjective or perceived task complexity can shed light on why the task performer perceives the task at hand to be difficult. No research has been done on the factors that identify the features or domains contributing to the perceived complexity factors for ID experts' decision-making process. In this study, we adopted the perceived complexity constituents from the literature review of Liu et al. used in other domains outside healthcare [23]. The four constituents we used for measuring perceived complexity are *diagnostic uncertainty*, *treatment unpredictability*, *perceived difficulty*, and *similarity* of the cases. Objective complexity has an important and direct relationship with subjective or perceived complexity [24]. As the complexity of a task increases, the task becomes more difficult for the performer and greater effort is needed to manage the complexity. Therefore, to understand the overall complexity, it is vital to take both perceived and objective complexity into consideration.

1.2. Objective

In this study, we are not trying to understand system complexity. Our goal is to better understand the psychological processes of humans coping with complexity. Therefore, understanding both patient and task complexity factors is crucial for identifying the specific factors contributing to complexity.

In a previous study, we developed and validated a clinical complexity measurement model that includes both patient and task complexity-contributing factors (CCFs) [25]. In the present study, we conducted provider observations to identify the specific CCFs in the ID domain and their relationship to perceived complexity.

In medicine, it is important for the clinician to have a good idea about how complex the situation of the patient is for improving overall care quality. Currently, there are no automated objective measurement quality indicators or software systems that can indicate the level of complexity for a difficult patient. Therefore, the determination of the complexity level of a patient case is based mostly on the subjective perception of the clinician. In this study, we seek to understand if the perceived complexity is correlated with the inherent or objective complexity of patient cases. Our findings can have important implications for future health IT system design that can support clinicians to reduce cognitive complexity and information overload. For example, systems that can classify different complexity levels of patients based on the information entered could objectively identify complexity. As human perception can be flawed, future smart systems can work as a cognitive extension for clinicians to correctly understand complexity in medicine. Future decision-support tools or software providing unbiased expertise can be of great benefit for treating complex patients with more preventive care.

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