Holistic healthcare modeling

A viewpoint on managing the complete patient care chain

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In the `80s, the reductionist method made famous by F.W. Taylor caused manufacturing industry to lose perspective of their overall factory. The approach, which focuses principally on analyzing individual components, fails to accurately account for their interactions. This narrow view was further compounded by the academic community which thrived on using reductionism for analyzing complex systems, ever the while increasing the gap between their research and actual practice. Throughout the `90s and still today, manufacturing is increasingly focusing on the entire supply chain. In healthcare this evolution is lagging.

In healthcare there are natural pressures that cause managers to lose sight of the overall perspective and take an individual component approach. This is further complicated when an "individual component" is a living and breathing patient thus creating an emotional justification for the approach. Perhaps due to the complexity, organizational makeup or even their reward structure, often "management does not consider the total care chain from admission to discharge, but mainly focuses on the performance of individual units. Not surprisingly, this has often resulted in diminished patient access without any significant reduction in costs" [1]. Additionally, healthcare managers typically have a background as a specialized care provider.

Healthcare modeling literature is ripe with studies on scheduling, resource utilization, and patient flow. However, these studies are often confined to the operation of a single department, ignoring many of the complex relationships that exist with other departments. As an example, patient arrival patterns are often modeled with statistical distributions instead of explicitly as a consequence of previous care. This disjointed approach fails to offer coordinated patient trajectories and essentially represents a hospital as a collection of processes mindlessly receiving patients from, and feeding patients into, buffers. From industry, we have learned that disjointed and unbalanced production lines lead to high buffer capacity, much work-in-progress, long product cycle times and they are plagued with inefficiencies. It is arguable that the impacts of disjointed operations are even more distressing in healthcare settings. Waiting patients, unlike waiting products, may phone the hospital if their wait is excessive, be prioritized and reprioritized, require ongoing care and cause other excessive coordination and management efforts. For inpatients these costs are high and direct, making the reduction of length of stay of patients a priority in hospitals and a common goal of many studies. For outpatients the costs associated with waiting for access to a service are not direct, often hidden, and not addressed in the healthcare literature. In addition to the administrative costs, the quality of life costs for patients cannot be understated. Besides the obvious extended period of time in poor health, there is anxiety associated with waiting, the possibility of further health deterioration, the loss of confidence in the hospital or physician, and furthermore, the compounded effect of all of these factors together.

Some headway is evident in the healthcare modeling literature. Many models consider the impact of their operations on the downstream impatient wards. Typical examples include bed occupancy being dictated by the operating room schedule, and ED congestion being caused by inability to admit patients to an already overcrowded ward. There is a pocket of literature concerning a hospital's inability to discharge patients into long-term care. Hospitals are developing ambulatory care centers that locate multiple specialties together so that a patient's ambulatory treatment can, at the least, happen in the same space, and at the best, be efficiently coordinated.

In our survey paper [2] we present a review of models used to examine issues related to patient flows, and determine the extent in which models account for interactions between the main department under study and adjacent departments. The review found 88 papers describing patient flow models that considered resources from multiple hospital departments. This amount is consistent with findings of other authors [3, 4] who conclude that although there is an abundance of models for healthcare processes, few consider multiple units or departments. All of the 88 models include the interactions with *downstream* departments, highlighting the importance that congestion in one department is often related to an inability to forward patients to a succeeding department. 30 of the 88 models, explicitly model the interaction with upstream departments. The remaining models use distributions to capture the variations associated with arrival patterns. Although this method is preferential to using only averages, it fails to distinguish between the variation caused by the random nature of illnesses and the variation induced by preceding departments. Such oversight may result in implementing complex policies to deal with variation instead of eliminating it at the source. Finally, although many patients require some type of diagnostics, only 13 models consider how diagnostic departments impact the flow of patients through the hospital. For a comprehensive literature database on quantitative healthcare models see [5].

Having argued the need for a holistic approach for healthcare management, we first need a better understanding of patient trajectories through multiple departments: "More sophistication in understanding the requirements of the environment, rather than ever more-complex models, is required" [6]. However, "patient care plans for the individual patient are rarely formally recorded, as such, they tend to evolve with the patient stay, and exist in a piece-meal fashion in the minds of physicians, nurses, and discharge planners" [7]. The literature offers some approaches to catalogue patient care trajectories. The most common approach is through discussions with managers and care providers [8, 9, 10]. More novel and automated approaches, involve using the information system protocol HL7 [7], medical record audits [11], billing code audits [12], radio frequency identifiers [13], bar codes [14] and other patient tracking systems [15].

On a more general level we find that researchers often take an atomistic view of hospitals, confine model scopes to a single department and overlook the complex relationships that exist in healthcare. We offer that this approach is in responses to two adverse but common characteristics of healthcare. The first is the complexity and variability that is inherent in healthcare and the second is the absence of standard patient care trajectories. We explain these challenges in more detail and discuss possibilities to overcome them.

The inherent complexity and variability of healthcare is in a way a double edged sword. On one hand its existence makes hospitals an ideal environment for applying operational research methods. On the other hand it either greatly limits the scope of models or forces modelers to take a more macro view. Either way, researchers loose a certain amount of perspective and perhaps draw conclusions on a model that does not incorporate the entire set of circumstances. Overcoming this challenge requires modelers to be able to distinguish between those complicating factors that have the greatest influence and those factors which are simply

attributes. This is of course is more of an art than a science and depends greatly on how intimately you understand the system. To limit the amount of variability one has to cope with in a model, time should initially be spent eliminating the variability caused by the system itself. This can often be achieved through good protocols or work practices and a clear understanding of the patient care trajectories.

The absence of standard patient care trajectories is as much a problem for management as it is a frustration for patients. Unfortunately when we do not know where patients are going we can not fully understand how the departments interact. Effort to standardize care and define patient care trajectories are a large part of clinical pathways, focused factories and lean/6-sigma projects. When successful, such initiatives can create environments where patient flows and department interactions are more apparent. This of course allows operational researchers to spend more time developing models and less time sorting through and accounting for the many complexities of the process.

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