**Solution:** A System Dynamics Approach to Strategic Inpatient Flow  
**Organization:** Johns Hopkins Medicine Center for Innovation in Quality Patient Care  
**Primary Contact:** David Baker, MBA, DrPH, Manager of Operations, Metrics, Patient Flow  
**E-mail:** davebaker@jhmi.edu  
**Type:** Acute Care  
**Phone:** 443.287.7068

**IDENTIFICATION:**
As in any complex system, causes and effects of actions related to acute care hospital patient flow can be distant in time and space. Optimally aligning the interactions within a system of patient flow may be especially challenging when individuals in different roles and settings view only portions of the larger system. This study explored the dynamics of patient flow in a neurosciences department of a large urban teaching hospital to better understand and control factors that threaten optimal access to care, clinical efficiency, and patient and care team satisfaction.

Physicians and nurses in the department had described recurring challenges in optimally moving patients through this inpatient care setting. Challenges included daily difficulties in identifying available beds for patients, variable and sometimes unpredictable patient inflow patterns, and delays in discharging patients who were medically ready to leave. Patient flow bottlenecks manifested themselves in delays or diversions, including turned away referrals due to bed unavailability and boarding of patients. Most of these undesired effects were not easily captured in department or hospital performance measures.

**PROCESS:**
System Dynamics methodology and software were used to develop models of patient movement through an ICU and nursing floor units, identify system constraints, and prioritize areas for interventions to facilitate sustainable improvements in patient flow.

The specific tools applied in analyzing the department’s patient flow included: interviews with multidisciplinary stakeholders in the patient flow process; mapping of the system’s structure to identify patient inflows, outflows, and accumulations; assessment of flow variables; iterative development of a computer simulation model using the Vensim System Dynamics modeling software; model testing; feedback on model structure and behavior from key staff; model refinement; and experiments of different scenarios and effects of variable changes on behavior of the system.

**SOLUTION:**
Data on patient flows through the department were collected and throughput simulation models were created in an iterative fashion with involvement of individuals who work within the system. The resulting dynamic simulation models demonstrated how the interplay of multiple factors across the continuum of care affected the efficiency of patient movement through the department. The relative impacts of potential interventions were tested. The models illustrated how the outflow patterns of one unit influenced the ability of another to accept new patients.
Model simulations indicated that expanding capacity in an ICU without also addressing floor unit capacity only exacerbated existing patient flow challenges.

Simulations of different structural and throughput scenarios demonstrated that patient flow behavior of the whole system appeared to be particularly sensitive to changes downstream, in the nursing floor units. Compared to changes in other system variables, interventions related to floor unit capacity and discharge processes were shown to yield larger and more sustaining improvements in overall system performance. The results support the findings of system dynamics research on larger health systems that additions to downstream capacity can both improve upstream problems and remove the need for excessive coping policies.

The findings of this initiative also indicated that the challenges of patient flow cannot easily be seen or addressed independently by unit managers. Rather, a departmental or hospital-wide approach is necessary to define system objectives and requirements, understand the relationships among system components, and align policies and resources to optimally meet system goals. The department now tracks performance through a “balanced scorecard” of patient flow measures. Leadership of this department is currently assessing short-term and long-term interventions to enhance downstream (floor unit) capacity.

Healthcare is comprised of many “tightly coupled, hard-to-see systems, and the naïve introduction of a change…might cause remote and dire consequences far away in space and time” (Berwick, 2008). Patient flow in hospitals is complex and influenced by a web of interdependencies among care providers, geographic locations and services. Localized interventions that do not consider the context of the broader system may result in a low return on invested resources or unintended consequences. System dynamics offers hospital leaders a practical tool to capture and make visible these interdependencies, understand how their interactions influence system behavior, and select optimal improvement strategies.