Staff optimization for time-dependent acute patient flow

The emergency department is a key element of acute patient flow, but due to high demand and an alternating rate of arriving patients, the department is often challenged by insufficient capacity. Proper allocation of resources to match demand is, therefore, a vital task for many emergency departments.

Constrained by targets on patient waiting time, we consider the problem of minimizing the total amount of staff-resources allocated to an emergency department. We test a matheuristic approach to this problem, accounting for both patient flow and staff scheduling restrictions. Using a continuous-time Markov chain, patient flow is modeled as a time-dependent queueing network where inhomogeneous behavior is evaluated using the uniformization method. Based on this modeling approach, we recursively evaluate and allocate staff to the system using integer linear programming until the waiting time targets are respected in all queues of the network. By comparing to discrete-event simulations of the associated system, we show that this approach is adequate for both modeling and optimizing the patient flow. In addition, we demonstrate robustness to the service time distribution and the associated system with multiple classes of patients.