Patient Scheduling

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Patient Scheduling

- Examples
  - surgery scheduling, doctor appointments, diagnostic, treatment therapy bookings, CAT scans, colonoscopy bookings
- Sources of randomness
  - arrivals and multiple priority levels
  - processing durations
  - no-shows and emergencies
- Types
  - advance scheduling
  - appointment scheduling (scheduling within a day)

Challenges

- Mismatch between capacity and demand
- Uncertainties
  - demand uncertainty (type and arrivals of patients)
  - service duration uncertainty
- Booking of multiple classes of patients
- No-shows
- Emergencies
- …..

Main Concepts

- Matching demand with capacity
  - capacity < demand ➔ backlog and waiting time ↑
  - capacity > demand ➔ backlog and waiting time ↓ (but maybe slow)
  - capacity = demand ➔ backlog and waiting time ?

- Reducing uncertainties / variability: process redesign, optimization and standardization
  - patient arrivals, patient types, no-shows
  - process durations
  - other aspects of operations such as late starts

- Effective scheduling
  - wait target time achievement
  - less waiting within a day: less idle time, less overtime, less wait time
  - less backlog in the queues

How to Reduce Wait Time/Queue Size?

- More efficient processing
  - decrease setups and idle times
  - specialization (e.g., all same/similar type of scans on a machine/day)
- More efficient scheduling
  - smoothing demand when possible, e.g., using lower priority patients to infill after higher priority patients are scheduled
  - determine appropriate service durations
  - overbooking, standby lists and other
- When possible,
  - capacity increase
  - demand decrease

How to Reduce Wait Time/Queue Size?

- Reduce uncertainty
  - standard exams and patient type definitions
  - best practices, process redesign and optimization
- Decrease no-shows
  - investigate why
  - reminders and confirmations, e.g., 1 week and 2 days before. if a patient did not confirm their appointment 2 days in advance, book someone else
  - let patients know that spots are scarce and precious resource, and they should inform in advance if they cannot make their appointment
  - let patients choose their own appointment time

How to Reduce Wait Time/Queue Size?

- Decrease no-shows
  - open access (same day appointment) concept (may not be suitable for certain exams and patient types)
  - if a no show (without a valid reason), book them at the latest possible time
  - book in the order of decreasing likelihood of no-show
  - overbook patients, have standby patients

How to Reduce Wait Time/Queue Size?

- Track patients with > target time and act upon, increase their priority or schedule them first in their priority
- Rebooked ones are more likely to show up
- Be flexible and do overtime when necessary
- Start on time, i.e., do not start late
- Book more complicated (e.g., longer) and variable cases later in the day rather than earlier in the day

How to Reduce Wait Time/Queue Size?

- Optimal appointment durations can be found to minimize total idle and over time mathematically, e.g., dome shape for identical appointments
- A central wait list or allowing patients to go from one place to another can help to achieve uniform wait times across the system
- Schedule high priority patients first and then start booking lower priority patients to the latest date allowed and move closer
- Use overtime judiciously to ease the load on the system from time to time

Overbooking (if medically allowed)

- Example: 10% no-show rate, 10 spots available, book 11 patients, i.e., 1 extra
  - if a patient fails to show up, you still have 10 patients for 10 spots
  - need overtime if all 11 shows up and some patients waiting time (during the day) may increase

- Bailey's rule: book 2 patients to the first sport at the beginning of the day to reduce idle time

Standby List

- Some patients may be
  - willing to be listed on a standby list with no specific appointment day for a shorter waiting time, and be available for an appointment with a short notice

- Inform them as soon as there is a spot available in the schedule. If no availability for a certain period of time (e.g., 2 weeks), overbook them (if medically allowed)

- Standby patients would be more likely to show up

Lessons from applied projects I

- Define an acceptable and achievable service criteria
- Be proactive rather than reactive when dealing with uncertain arrivals
- Try to set Capacity > Demand
- Know what is sensitive /critical for your system
- Improve and optimize processes/operations constantly

Lessons from applied projects II

- Process redesign and optimization
  - e.g., efficient set up and recovery, hire staff when needed
- Identify true bottlenecks
- Think of doing things to utilize the expensive resources more
- Try to set Capacity > Demand
- Collect operational data, analyze data, use data, report performance across different units and compare
- Consider temporary solutions to clear backlogs
- Scheduling policy matters

Lessons from applied projects III

- Smooth your demand when/if possible
- Use of sophisticated mathematical models to solve complex problems
- Better scheduling can lead to more efficient outcomes
- Savings are more if overall system can be considered together

What is Management Science / Operations Research?

- Different names but similar concept: Analytics, Quantitative Decision Making, Industrial Engineering, Process optimization
- A collection of scientific methods of providing decision-makers (e.g., operational, financial) a quantitative basis for their decision making at strategic, tactical and operational levels.
- Data → information →knowledge→ understanding → better outcomes/policies
  - evidence based decision making in going from data to policy
- Mathematical modeling, optimization, simulation, decision analysis, queuing theory, probability, forecasting, statistics, game theory

Examples of Questions OR/MS can Help

- Capacity expansion at a hospital / health authority
  - alternative and scenario planning and analysis
  - projection, forecasting, prediction of future demand
  - taking into account uncertainties
- Scheduling (e.g., patients, appointments, surgeries, staff)
- Process redesign and optimization (e.g., porter operations, radiation therapy)
- Waitlist management
- Medical decision making (e.g., beam optimization, initiation of drug therapy)
- Sample projects
  - Patient CT waiting time reduction study for an hospital
  - Improving patient throughput at a Children's Hospital
  - Managing surgical waitlists for an Health Authority

Some References

- Mehmet A. Begen and Maurice Queyranne, “Appointment scheduling with discrete random durations,” Mathematics of Oper. Res., 36-2: 240-257, 2011

- Pablo Santibáñez, Mehmet Begen, Derek Atkins, “Surgical block scheduling in a system of hospitals: an application to resource and wait list management in a BC health authority,” Health Care Man. Sci., 10: 269-282, 2007

- Patrick, J., Puterman, M.L. and Queyranne, M. 2008, “Dynamic Multi-Priority Patient Scheduling for a Diagnostic Resource,” Oper. Res., 56(6): 1507-1525.

- For more references and information on projects visit http://www.ivey.uwo.ca/faculty/mbegen/