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Reallocating a Portuguese public hospital's operating room time

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Highlights

- ✓ Generate a Master Surgery Schedule (MSS) considering three objectives that are not studied together in the literature
- ✓ Long planning horizon to handle fluctuations in surgical demand pattern
- ✓ Weekly target OR time to each specialty calculated based on: estimated time required for all the surgeries on the waiting lists, results from previous decisions and new entries on the waiting list

Objective

Allocate OR time slots to surgical specialties:

- Comply with dynamic demand
- Consider stakeholders' preferences
- Balance workload in up- and downstream units

Motivation

Increasing complexity of health care organizations

Aging population
Increasing demand
Development of new and expensive technologies

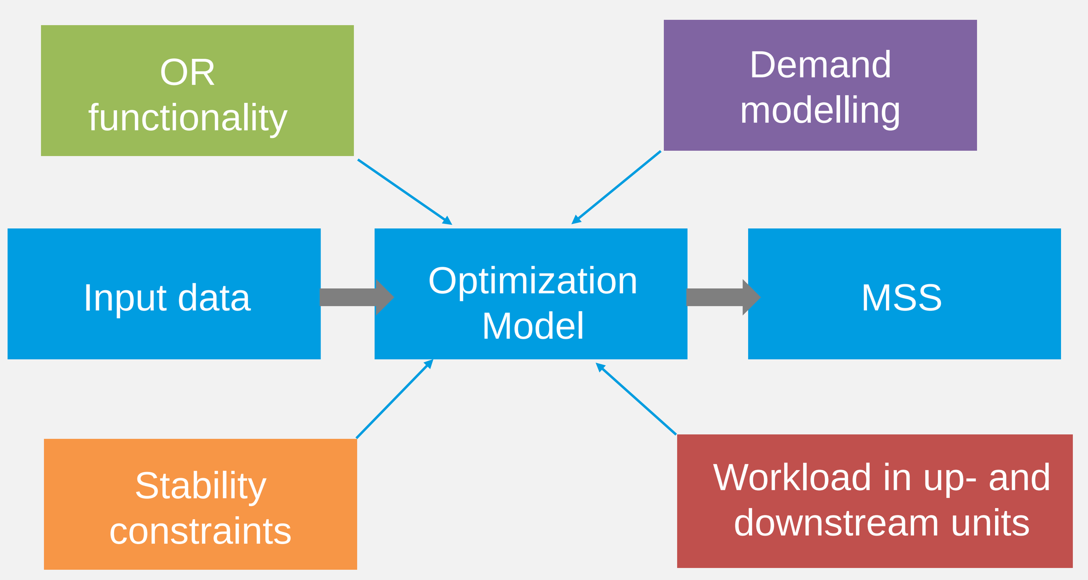
Operating rooms are the center of costs of an hospital

Coordination with restrictive resources

Lack of surgeons
Lack of anesthesiologists
Lack of beds

Model

Structure:



Main parameters:

$s \in S$ specialties
$w \in W$ weeks
$d \in D$ weekly working days
$k \in K$ days in the planning horizon; the first day of the planning horizon is $k = 1$
$r \in R$ operating rooms
$b \in B$ shifts
$i \in I$ surgeons
$a \in A$ anesthesiologists
$z \in Z$ up- and downstream units

$$t_{sw} = p_{sw} dur_s \quad \forall s \in S, w \in W$$

κ^{surg}_{idb} preference score for surgeon i to work on shift b on day d
κ^{anest}_{adb} preference score for anesthesiologist a to work on shift b on day d
w_z relative weight of unit z
u_{zk} target utilization for unit z on day k
t_{sw} target time allocation for specialty s in week w
p_{sw} number of patients of specialty s on the waiting list in the beggining of week w
dur_s average duration of a surgery of specialty s (in hours)

Objective function:

$$\max \quad \sum_{s\in S}\sum_{w\in W}\sum_{d\in D}\sum_{b\in B}\sum_{r\in R}\left(\frac{\sum_{i\in I_s}\kappa^{surg}_{idb}}{|I|} + \frac{\sum_{a\in A}\kappa^{anest}_{adb}}{|A|}\right)x_{swdbr} - \frac{1}{|W|}\sum_{s\in S}\sum_{w\in W}(t^-_{sw}+t^+_{sw}) - \sum_{z\in Z} w_z \sum_{k\in K}\frac{u^-_{zk}+u^+_{zk}}{u_{zk}}$$

Decision variables:

x_{swdbr} 1, if specialty s is assigned to OR r on week w, day d and shift b; 0, otherwise
t^-_{sw}, t^+_{sw} negative and positive deviations of the allocated time to the target value for specialty s on week w, respectively
u^-_{zk}, u^+_{zk} under and overutilization of beds on unit z on day k (compared to the target utilization value), respectively

Case-study

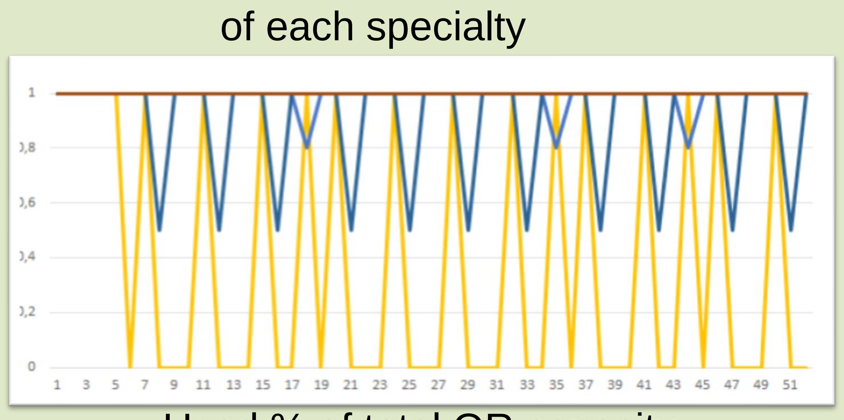
- Portuguese public hospital
  - Serves 325.237 people
  - 5 operating rooms
  - 8 surgical specialties
- Changes in surgical demand
  - 2007: 1600 patients in the waiting list
  - 2017: 4000 patients in the waiting list
- Almost unchanged MSS for more than 30 years
- High waiting time for elective surgeries
  - 24,20% of the patients on the waiting list wait more than the maximum recomended time before surgery
- High rates of unutilized OR time

OR1	OR2	OR3	OR4	OR5	Total
33.5%	30%	16.7%	30%	93.3%	48.5%

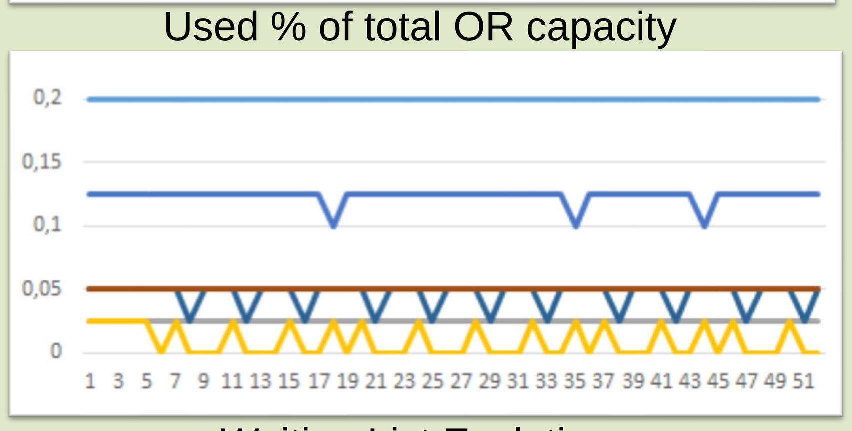
Results

Real Instance:

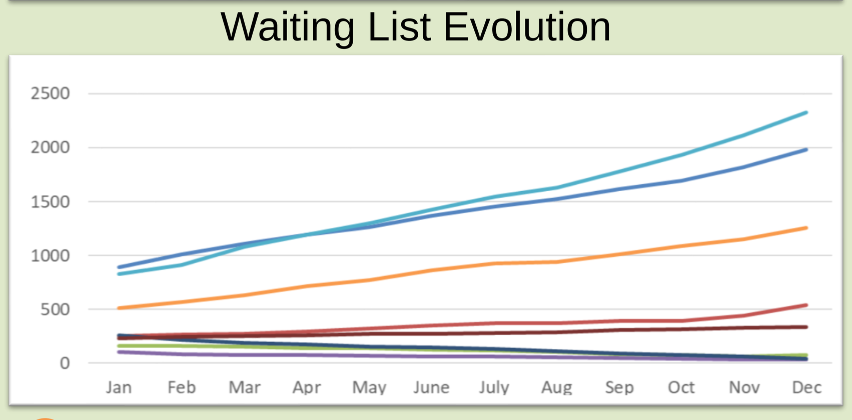
Used percentage of the maximum capacity of each specialty



Used % of total OR capacity

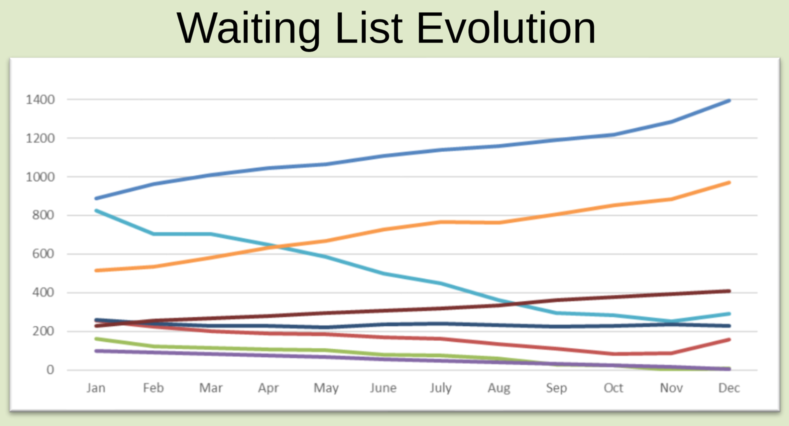


Waiting List Evolution



- Specialties at maximum capacity
- Low compliance demand-supply
- Only ~55% of slots assigned

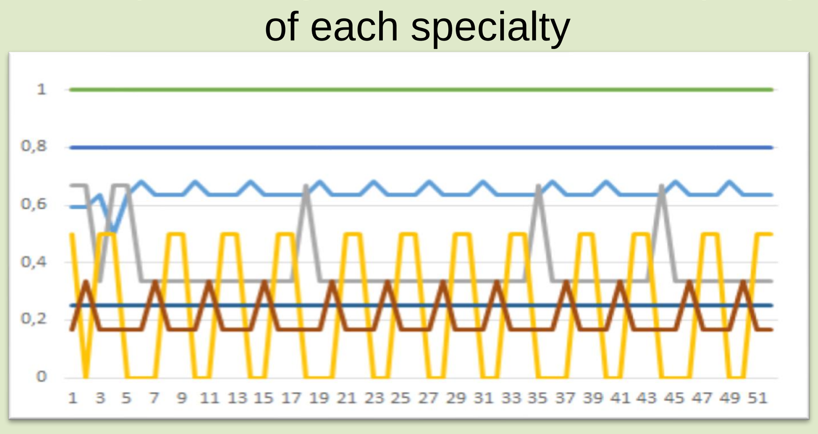
Waiting List Evolution



- More flexibility regarding capacity
- Better compliance supply vs demand
- About 95% slots assigned

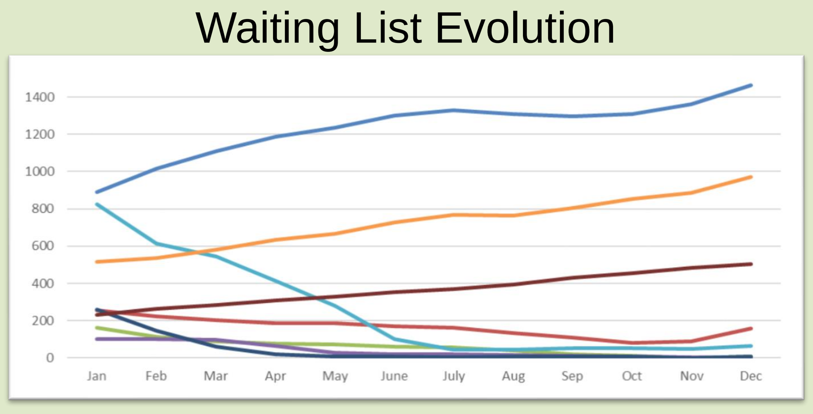
Increased Work Capacity:

Used percentage of the maximum capacity of each specialty

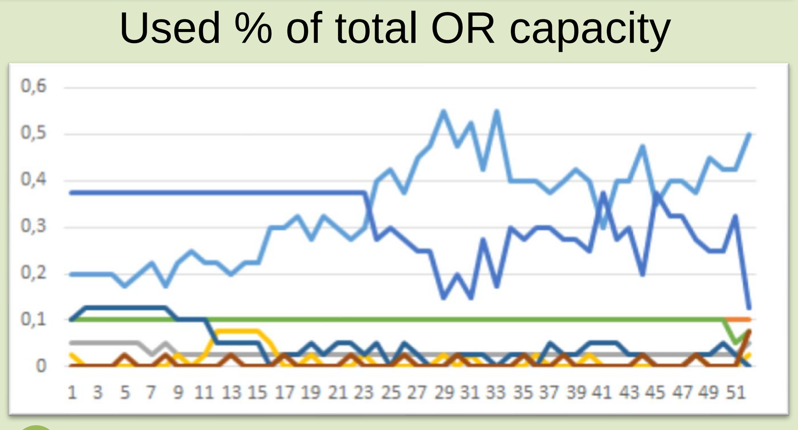


Increased Work Capacity without Stability Constraints:

Waiting List Evolution



Used % of total OR capacity



- More flexibility to chase demand
- Potential to schedule more patients
- About 95% slots assigned
- Doctors not satisfied

Legend:

General surgery, Plastic surgery, Pediatric, Stomatology, Ophthalmology, Orthopedics, ORL, Urology

Conclusions and future work

- Workforce is the main **drawback** in complying with dynamic demand fluctuations
- Stability constraints impact the expected total number of scheduled patients at the end of the planning horizon
- **Future work**:
  - Sensitivity analysis on stability parameters
  - Consistent models for stakeholders' preferences
  - Predictive model for demand forecast
  - Simulation model
  - Evaluate occupation levels based on preferences

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