Assessing the impact of patient prioritization on operating room schedules

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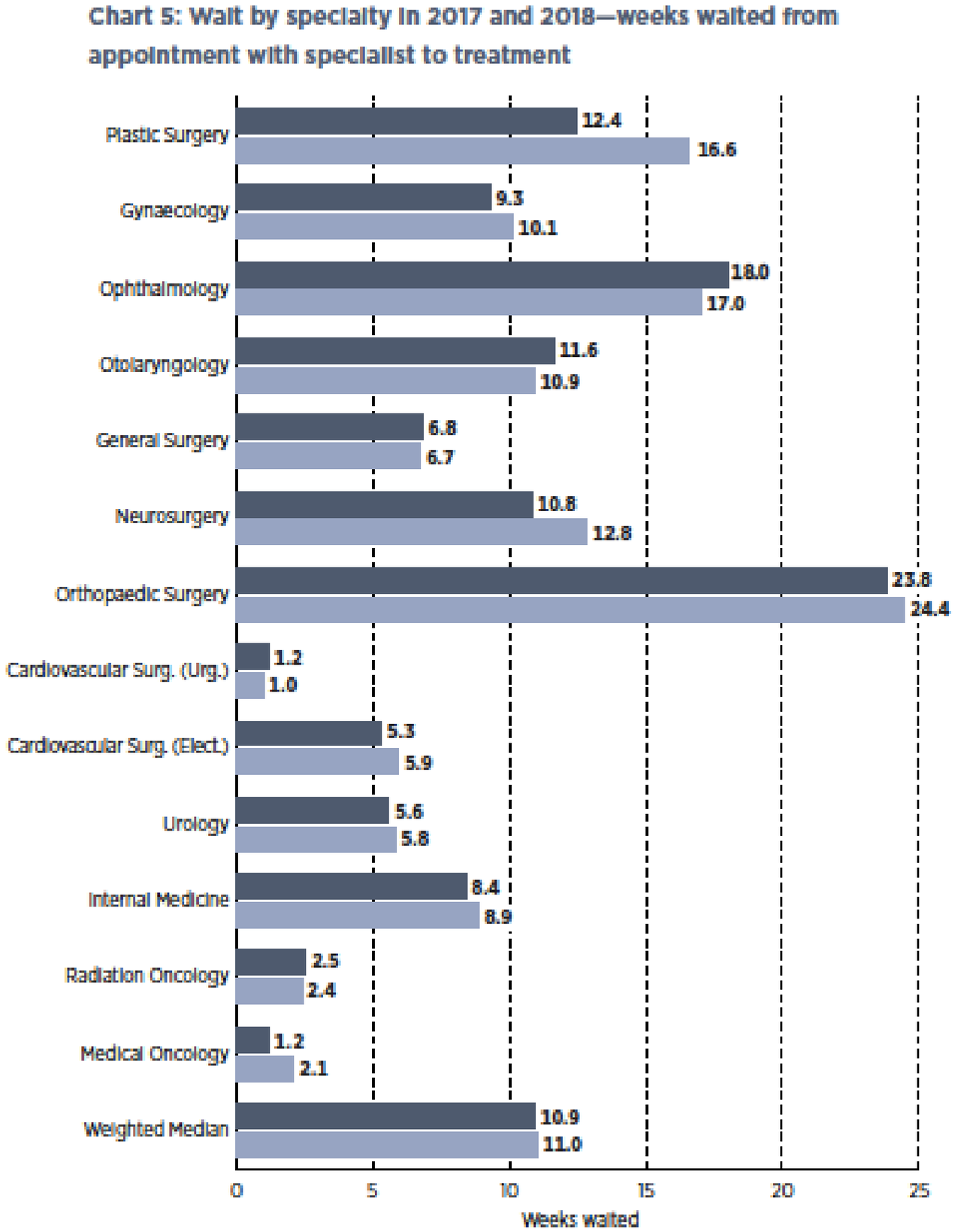

Waiting arise at different steps in the healthcare system

Waiting lists help streamlining the uncertainty of request and the workload of providers in almost any service context

Demand exceeds capacity, waiting lists grow quickly

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Context

Graph 14: Quebec—actual versus reasonable waits between appointment with specialist and treatment, 1994 to 2018

Source: The Fraser Institute's national waiting list surveys, 1995–2018.

Some strategies to address waiting lists

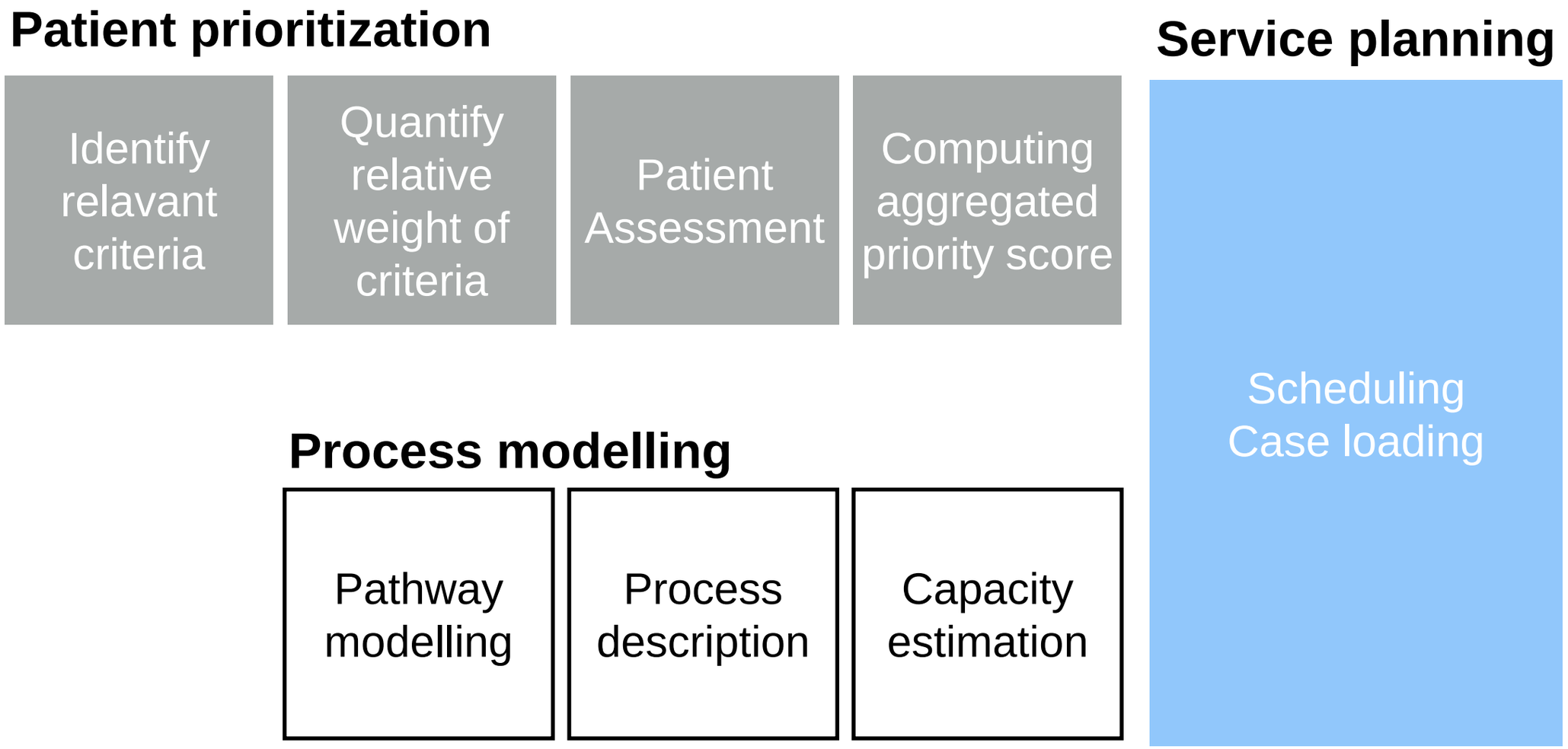
- Reducing demand
  - Implementing cost-sharing mechanisms
  - Better target the needs
- Increase capacity
  - Dedicating special envelopes for the reduction of waiting lists for very specific cares
- Examine potential efficiency gains using current resources
  - Improve the processes
  - Ultimately reduce wait times
- Select patients that should receive the services first
  - Use patient prioritization methods to ensure that patients with higher need receive services ahead of those with less urgent need

Patient prioritization

“ Patient prioritization refers to the process of ranking referrals in a certain order based on various criteria with the aim of improving fairness and equity in the delivery of care (Harding and Taylor, 2013)“

- Assessing patients’ priority tends to be an inconstant practice (Harding et al., 2009)
- Absence of systematic and standardized practice for patient prioritization
- “Low-priority” patients, such as persons with chronic conditions, are not receiving publicly accessible healthcare services in timely manner (Passalent et al., 2009)
- **Patient prioritization is linked with the planning of activities**

General methodology



General methodology

Patient prioritization

Identify relavant criteria	Quantify relative weight of criteria	Patient Assessment	Computing aggregated priority score

- Driving evaluation program
- Compression garment-manufacturing program for burn victims
- Orthosis/prosthesis program

« *The concept of need goes beyond the medical perspective and incorporates wider social and environmental determinants associated with a sustainable vision of health* (Wright et al. 1998) »

General methodology

Patient prioritization

- Identify relavant criteria
- Quantify relative weight of criteria
- Patient Assessment
- Computing aggregated priority score

Service planning

Scheduling
Case loading

Process modelling

- Pathway modelling
- Process description
- Capacity estimation

- Urology department

« *Transform surgery scheduling in a more equitable process taking into account patients' needs* »

Research questions

- Is the use of an objective function designed to maximize utility deteriorate the efficiency compared to first-come, first-served policy?

- How the use of such an optimization tool affects both in the short and long terms the wait times for the different patients on the list?

Planning in OR

- **Long-term**: dimension the capacity to strategically answer the current and expected surgical demand.
- **Medium-term**: allocate the capacity to surgical specialties and build the master surgery schedule (MSS).
- **Short-term**: select and schedule patients on the waiting list to a given surgical session (surgical case assignment problem) and order them within the assigned timeslot

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  - **Surgical case assignment problem**: select patients from a waiting list and assigned them to an available timeslot of the related specialty according to the MSS designed in the medium-term decision level

Planning in OR

Objectives

- Operational: maximizing utilization and throughput or minimizing overtime and costs (Marques et al., 2012; Cappanera et al., 2018; Hans et al., 2008; and Min and Yih, 2010a)

- Patient perspective: waiting time often used to prioritize patients on the list for surgery (Durán et al., 2017; Marques and Captivo, 2017; and Rachuba and Werners, 2014)

Other characteristics

- Uncertainty: surgery duration (Marques and Captivo, 2017; Addis et al., 2016; Landa et al., 2016)

- Up and downstream resources: levelling the use of resources (Cardoen et al., 2009) and include the capacity of resources such as beds or staff (Min and Yih, 2010a)

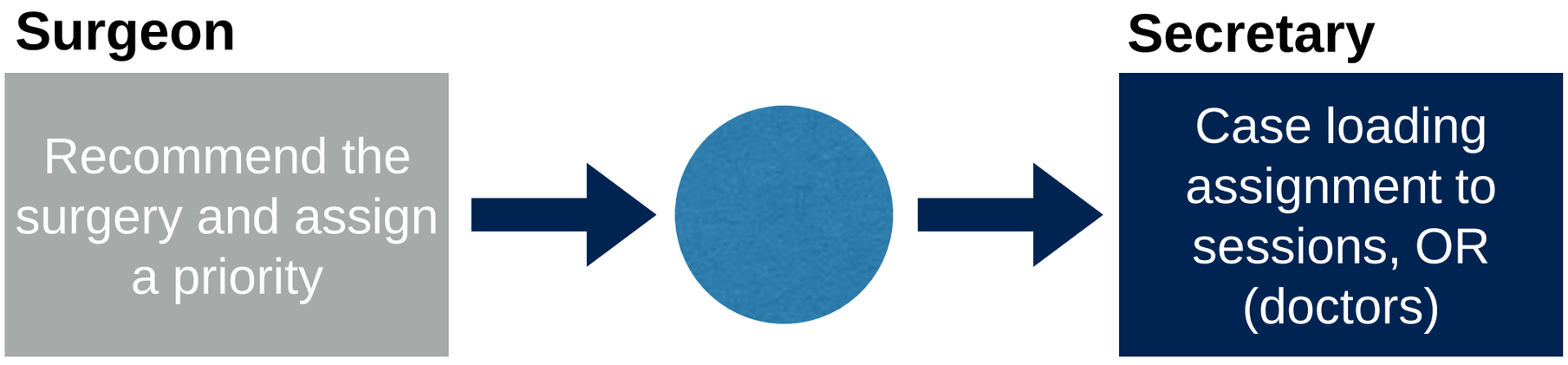
Waiting list management

- Legal guidelines suggest the selection of patients according to priority level and waiting time:
  - Patients with higher priority level should be selected first
  - Among the same priority class, patients should be selected according to their wait time
- This approach assumes that:
  - All the patients in the same priority level have equal needs
  - Health status evolution during the waiting time is the same for all patients within the same priority level
- 97% of 2,000 surgical waiting patients belong to the lowest priority level among 4 priority classes (Marques et al., 2012)

Case study

- One of the five hospitals integrating the University Health Centre in Quebec City
  - 13 500 employees and providing care services to 2 million people
  - 25 major medical specialties
  - During the 2016-2017 period, 67 088 surgeries performed
  - On average, 216 new elective surgery requests arrive every day
- Prioritization system for elective surgery is based on a set of discrete priority levels (P1 to P4) that limit the acceptable waiting time
  - P1: 2 weeks
  - P2: 4 weeks
  - P3: 12 weeks
  - P4: 1 year

Case study



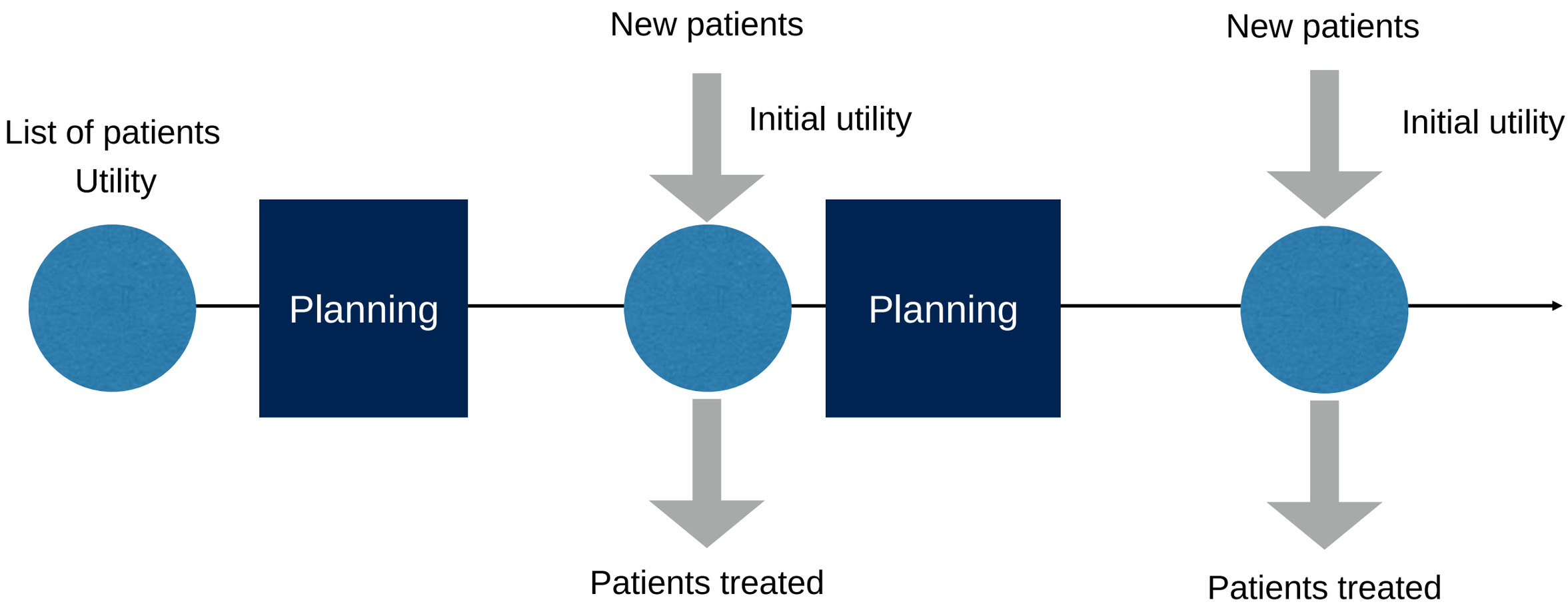
Urology department

Master surgery schedule : 12 sessions per week (1-day session)

4 to 6 surgeries scheduled by 1-day session.

5 major types of surgeries or subspecialties that require different skills

Solution framework



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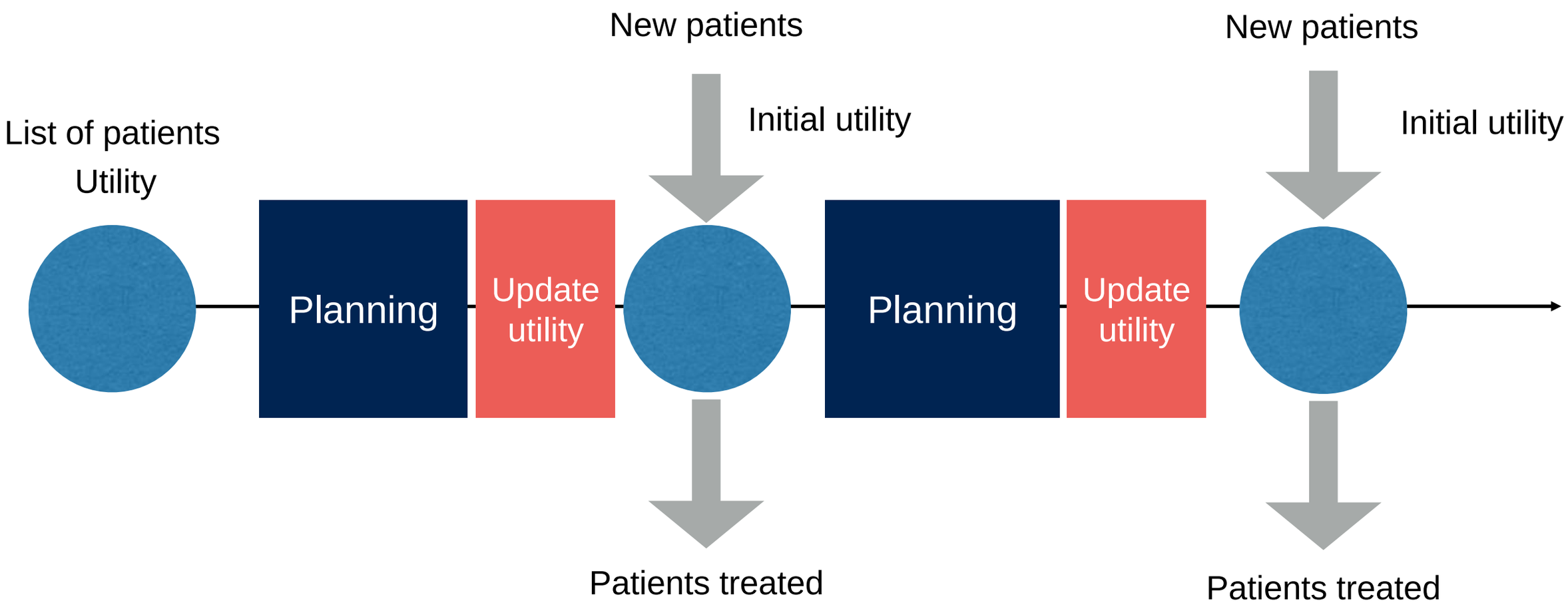

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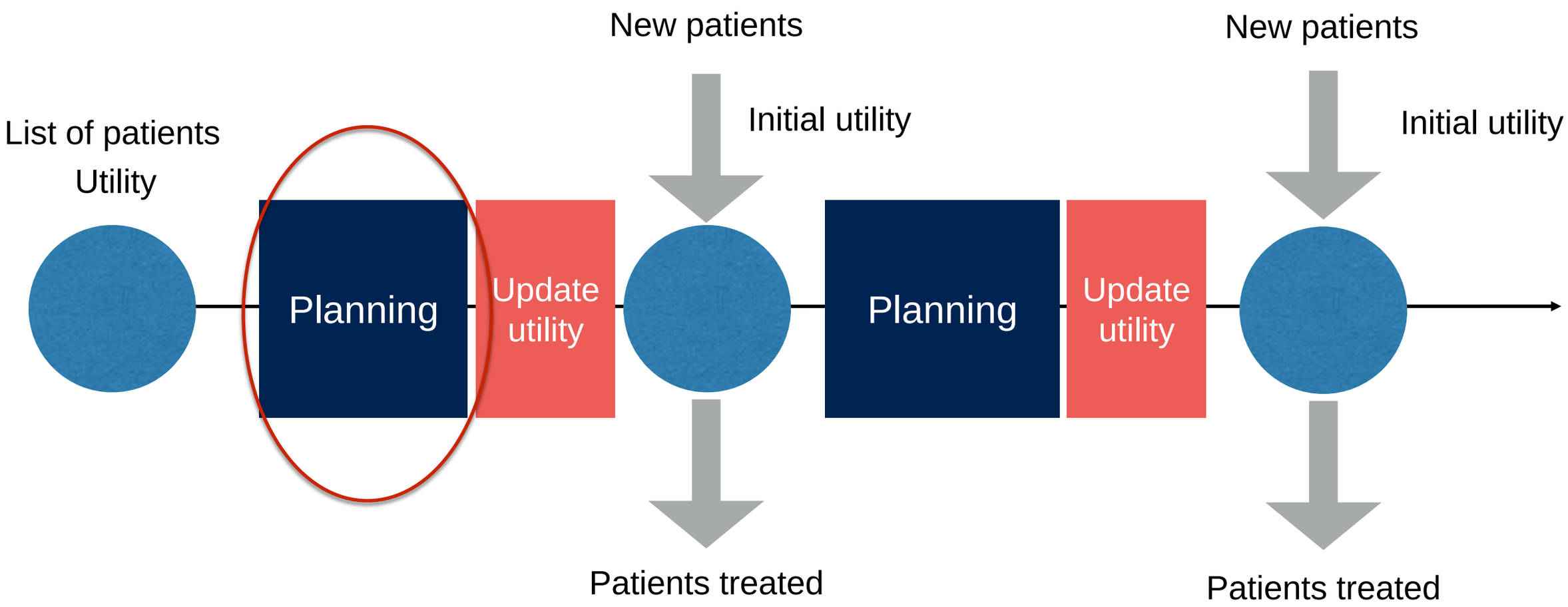

Mathematical formulation

$$Maximize\ \Delta_1 \sum_{s\in S}\sum_{p\in P}\sum_{d\in D_s}\sum_{o\in O}\frac{\mu_p x_{spdo}}{s} + \Delta_2 \sum_{s\in S}\sum_{p\in P}\sum_{d\in D_s}\sum_{o\in O}\kappa_{pd} x_{spdo} - \Delta_3 \sum_{s\in S}\sum_{o\in O} z_{so} \quad (1)$$

Utility — Pre-assigned doctor — Overtime

Capacity

$$\sum_{p\in P}\sum_{d\in D_s}\tau_p\,\phi_{dp}\,x_{spdo} \le \eta_s + \delta_s z_{so} \qquad \forall\, s\in S, o\in O \quad (2)$$

Assignment

$$\sum_{s\in S}\sum_{d\in D_s}\sum_{o\in O} x_{spdo} \le 1 \qquad \forall\, p\in P \quad (3)$$

Doctor's skills

$$x_{spdo} \le \varphi_{dp} \qquad \forall\, s\in S, p\in P, d\in D_s, o\in O \quad (4)$$

One session per day

$$\sum_{o\in O} y_{sdo} \le 1 \qquad \forall\, s\in S, d\in D_s \quad (5)$$

Minimum number of sessions

$$\sum_{s\in S}\sum_{o\in O} y_{sdo} \ge \lambda_d \qquad \forall\, d\in D_s \quad (6)$$

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Utility — Pre-assigned doctor — Overtime

Available sessions $\sum_{d\in D_s}\sum_{o\in O} y_{sdo} \leq \gamma_s \quad \forall\, s \in S \quad (7)$

$$x_{spdo} \leq y_{sdo} \quad \forall\, s \in S, p \in P, d \in D_s, o \in O \quad (8)$$

$$\sum_{p\in P} x_{spdo} \geq y_{sdo} \quad \forall\, s \in S, d \in D_s, o \in O \quad (9)$$

$$x_{spdo}, y_{sdo} \in \{0,1\} \quad \forall\, s \in S, p \in P, d \in D_s, o \in O \quad (10)$$

$$z_{so} \in \{0,1\} \quad \forall\, s \in S, o \in O \quad (11)$$

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Generation of instances

- System’s characteristics
  - Initial population of 200 patients
  - 2-week schedules - 10 operating days (480 minutes per session)
  - 150 patients enter the system at each period 200 patients (every two weeks)
  - Number of sessions per day is linked to the master schedule plan
  - 8 surgeons and 5 types of surgeries
- Patient’s characteristics
  - Score: N(65,15)
  - Surgery duration: surgery times provided by the CHOIR group of University of Twente
  - Pre-assigned doctors: U(1, 8)
  - Number of sessions from the patient arrival on the list: U(0,20)

Generation of instances

- Doctor’s characteristics
  - Doctor skills: Bernoulli distribution, in which there is a 70% chance of “being capable’’
  - For each surgery that a doctor can perform, its relative speed: U(0.8; 1,2)
  - Each doctor do at least 2 sessions per planning period
  - Available doctors for each session: Bernoulli distribution in which there is a 90% chance of a doctor being available on a certain session

One-period horizon

	Av. Utility				Av. Waiting sessions				Performed Surgeries		Max. Wk	
	Scheduled		Unsched.		Scheduled		Unsched.					
	UM	WM	UM	WM	UM	WM	UM	WM	UM	WM	UM	WM
I1	69.77	64.56	55.83	66.91	15.06	17.66	19.81	14.64	137	131	4	4
I2	68.95	64.65	59.11	66.91	15.18	17.51	19.26	15.33	130	124	4	4
I3	69.46	65.60	57.08	63.63	15.26	17.78	20.29	16.33	125	121	5	5
I4	70.92	67.05	60.53	67.99	14.53	16.52	20.03	16.38	132	128	4	4
I5	69.53	65.75	58.32	65.26	14.15	16.74	19.49	16,00	129	118	4	4
I6	69.89	63.34	55.96	66.4	14.80	17.77	21.04	16.49	124	118	4	4
I7	67.43	63.22	55.69	64.95	15.22	17.10	18.95	15.05	138	134	6	6
I8	67.10	64.47	60.12	67.48	13.87	16.60	19.77	15.49	126	118	4	4
I9	66.66	62.84	55.03	62.78	14.37	17,00	19.71	15.19	134	122	5	5
I10	69.14	63.78	56.52	67.32	14.76	17.27	19.54	14.92	135	129	5	5
Av.	**68.88**	**64.52**	**57.41**	**65.96**	**14.72**	**17.19**	**19.78**	**15.58**	**131.0**	**124.3**	**4.5**	**4.5**

UM: Utility defines as a score

WM: Utility linked with the waiting time

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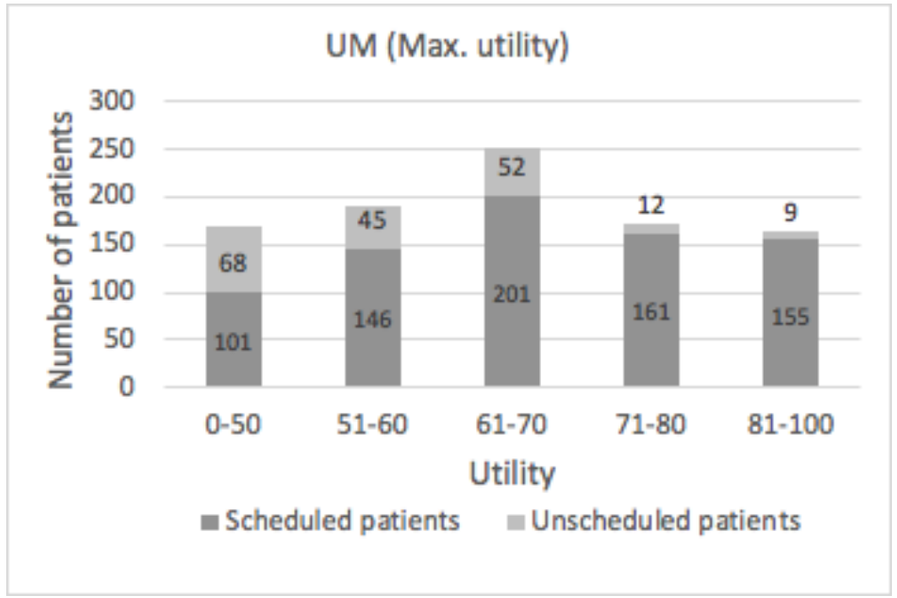

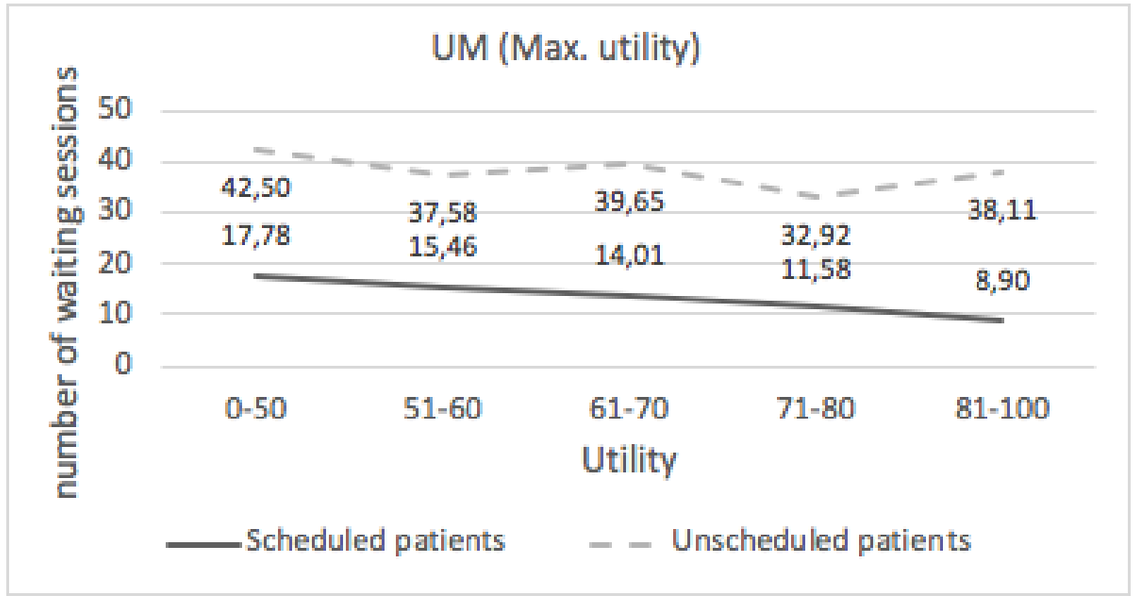

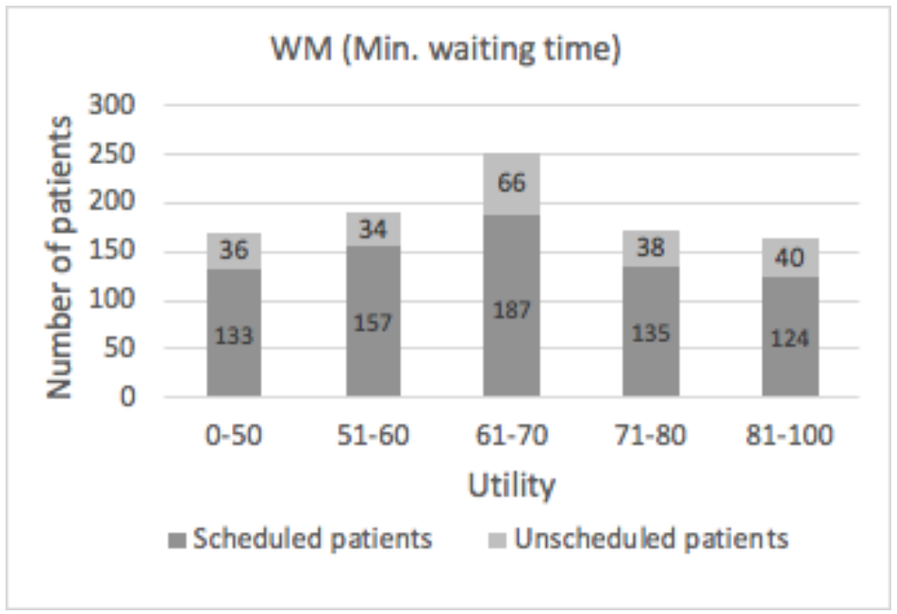

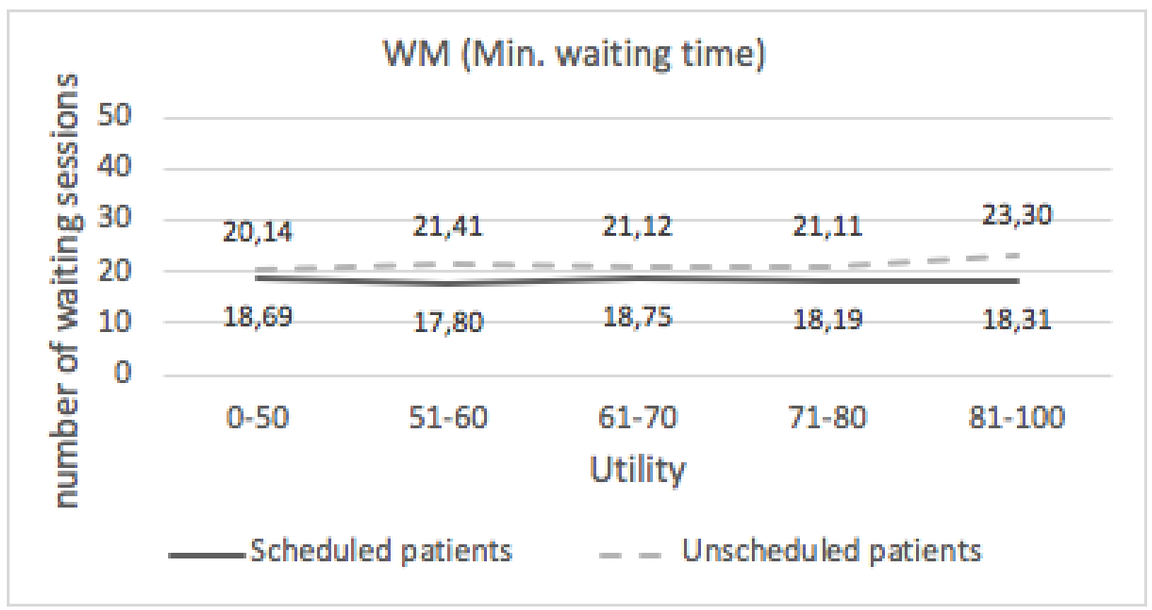

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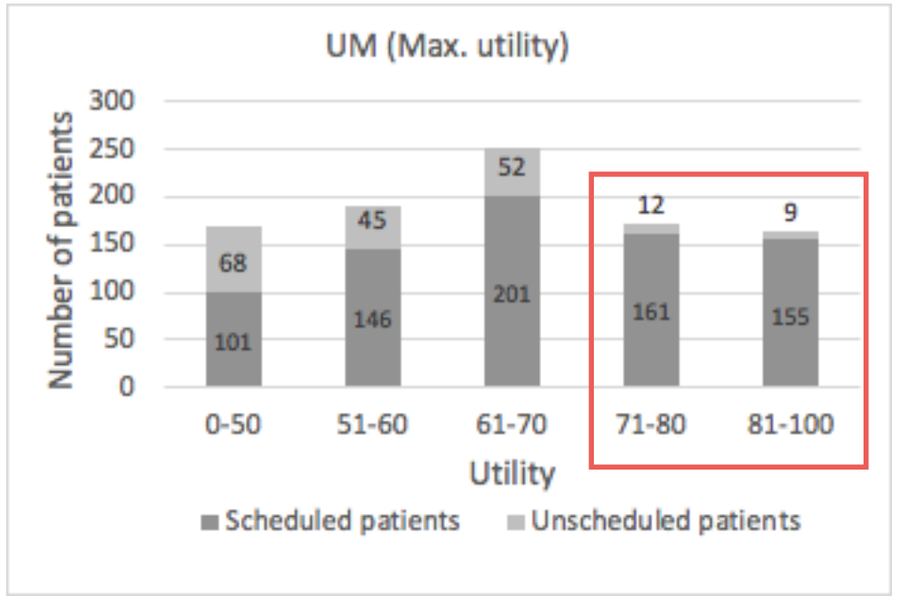

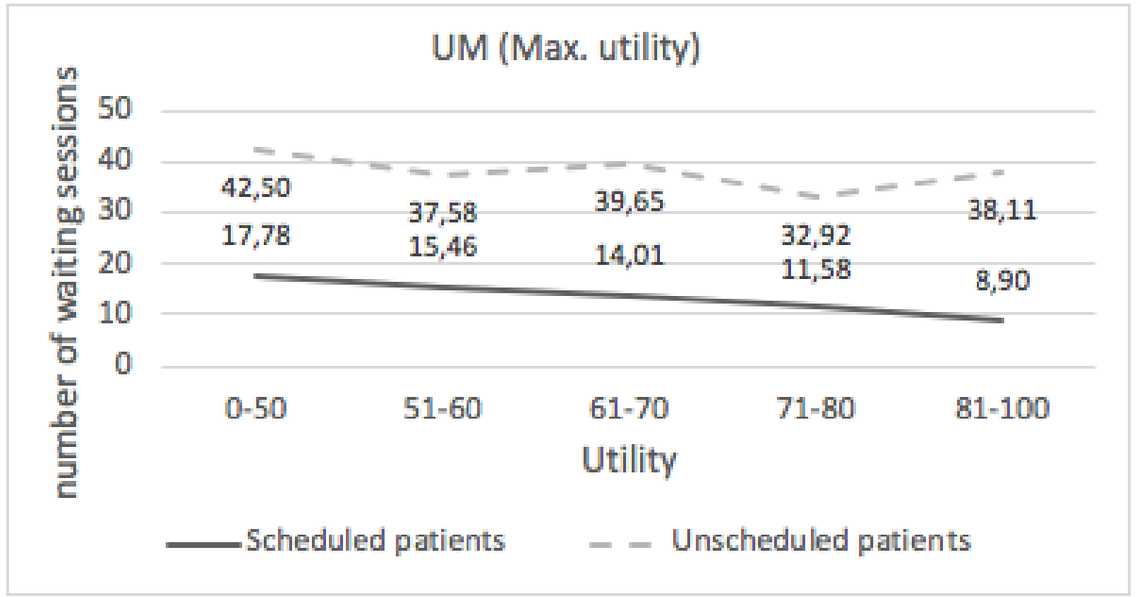

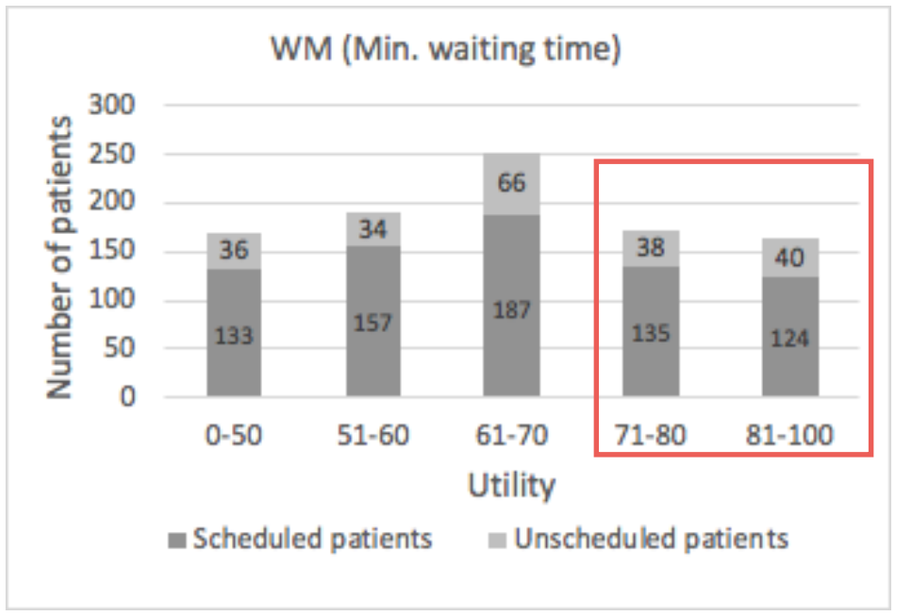

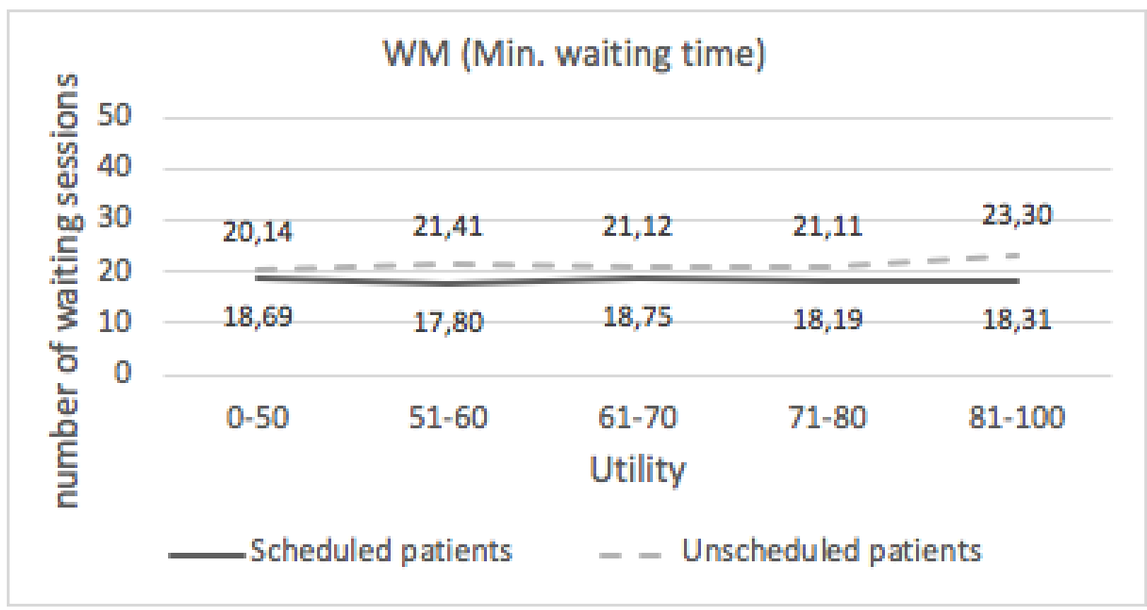

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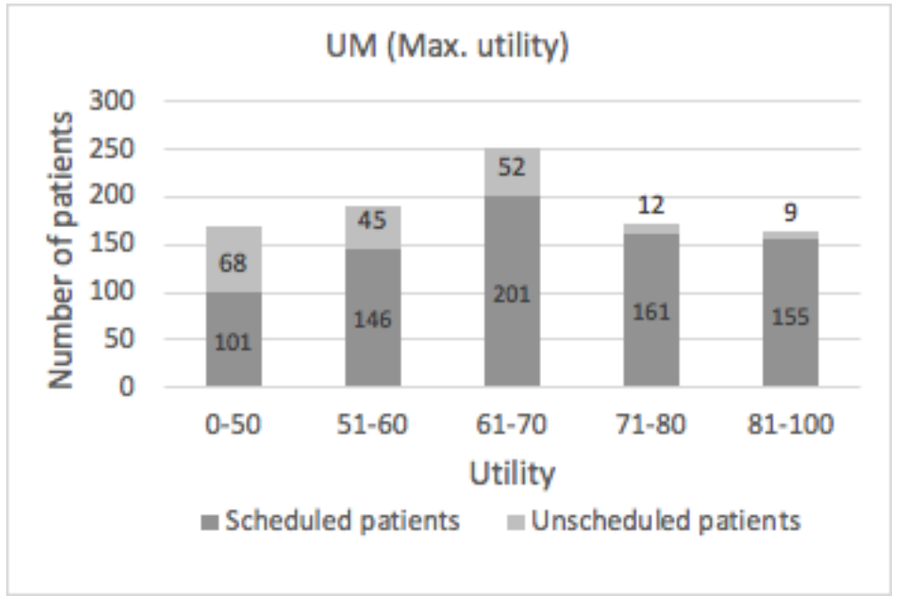

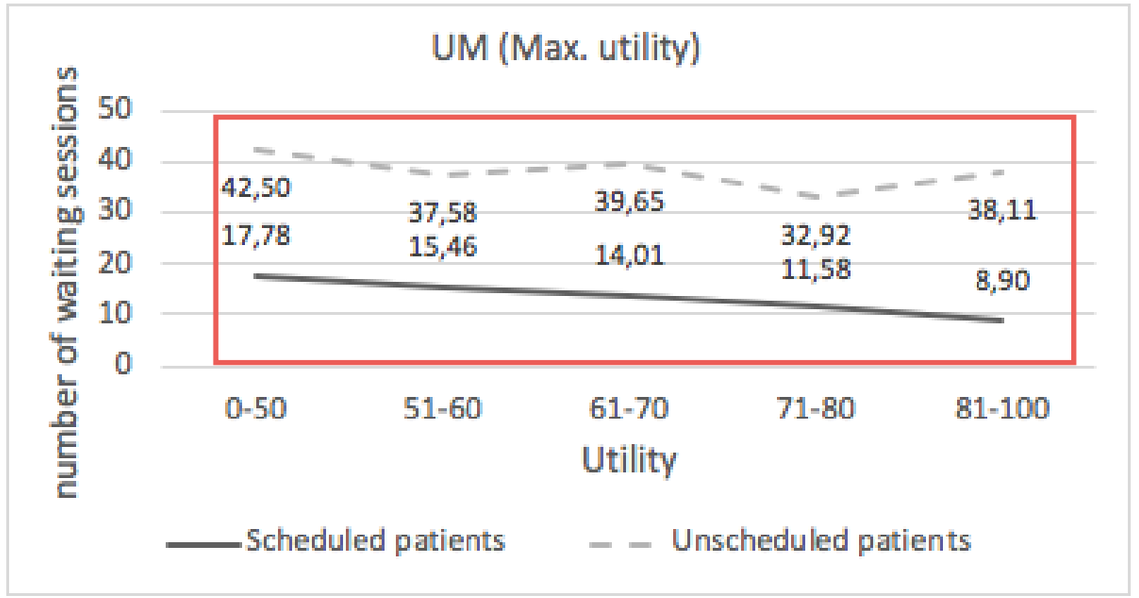

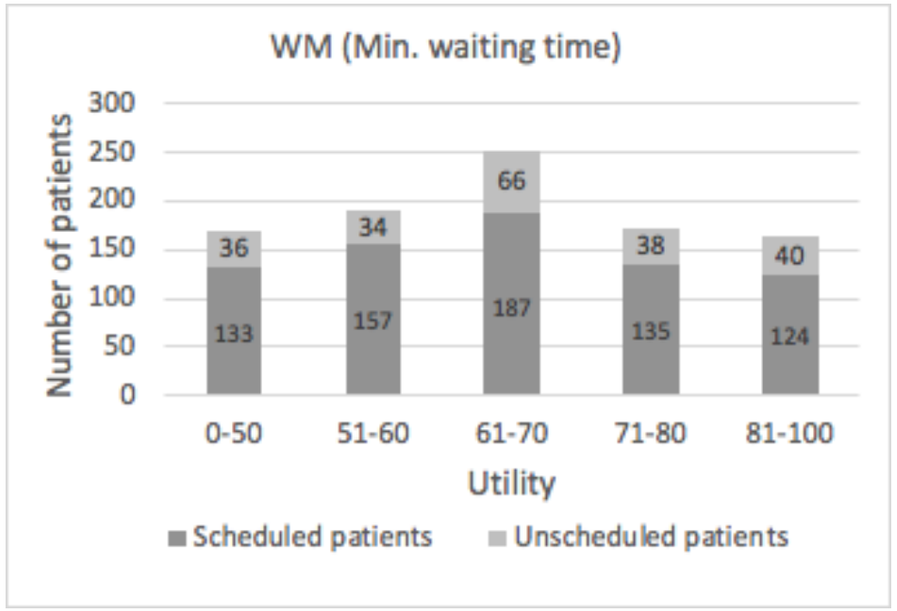

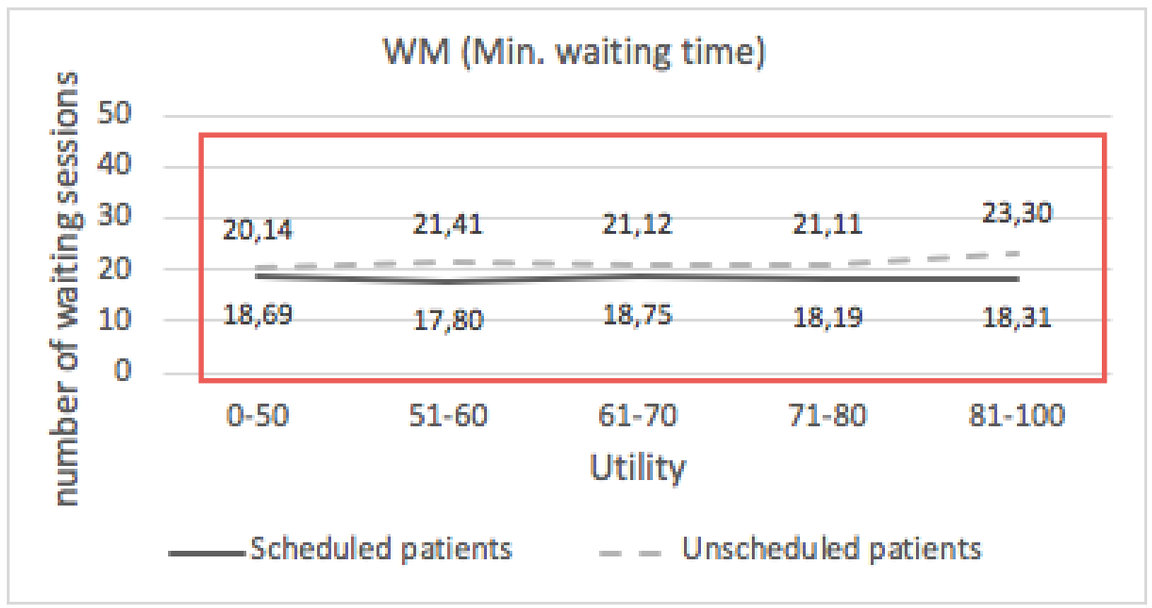

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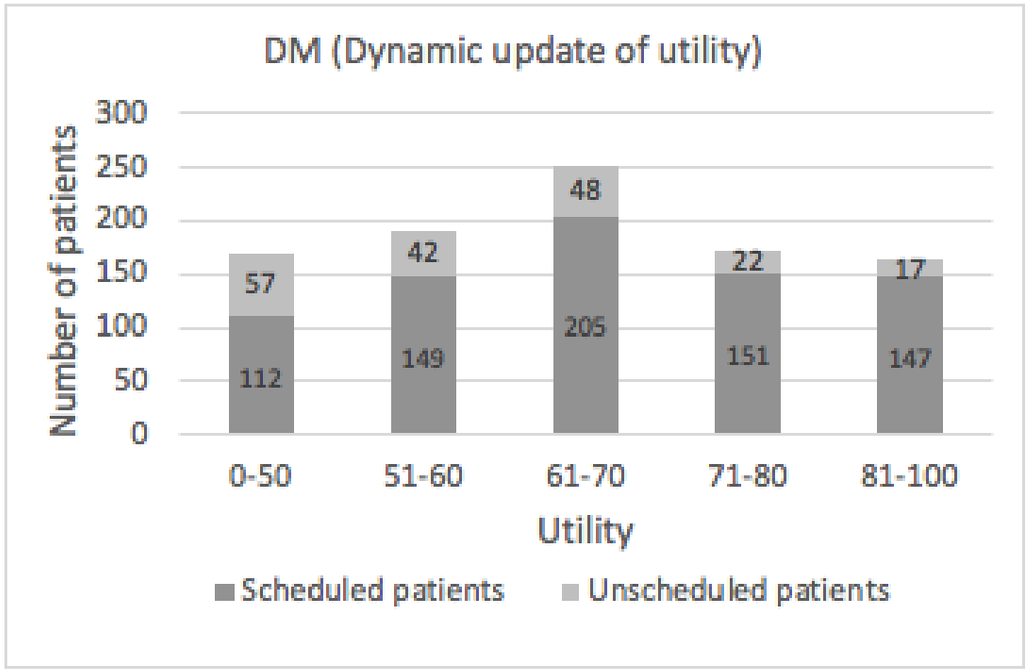

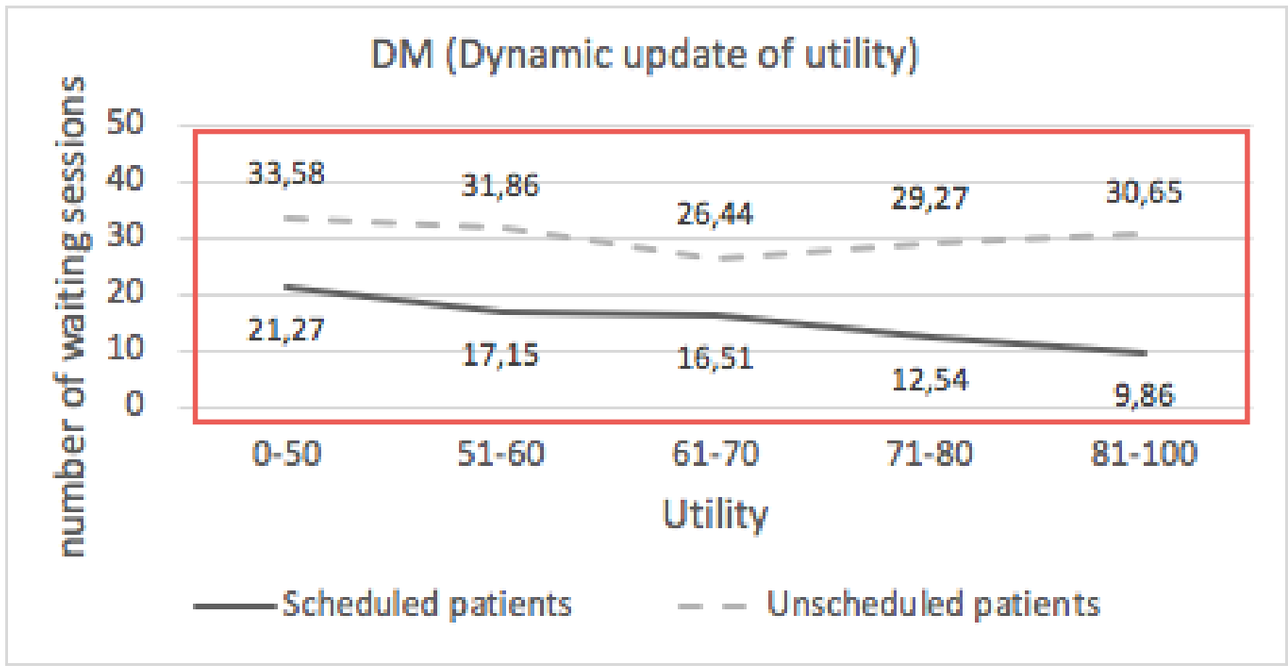

- The utility is multiplied by a random factor between 1 and 1.3.

Conclusion and future work

- Build a framework to investigate the impact of patient prioritization
- Show some benefits of taking needs of the patient in addition to wait times
- Improve the optimization part
- Study different mechanisms to update the score
- Evaluate parameters to help implement such a strategy in practice
- Improve the framework, including simulation

Comments and questions?

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