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Operating room time allocation to surgical services: the case of a public hospital in Portugal

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Portugal

OpLog Research Group

OUTLINE

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- Introduction — ImproveOR project
- Motivation — Case Study
- Problem Description — Objectives, Literature Review, Methodology, Model
- Preliminary results
- Conclusions
- Future work

IMPROVEOR PROJECT

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CENTRO HOSPITALAR LISBOA NORTE, EPE | HOSPITAL DE SANTA MARIA | Hospital Pulido Valente | Hospital do Espírito Santo Évora E.P.E

- Propose changes to resource planning and scheduling on the operating rooms
- Improve operating rooms efficiency
  - Increase surgeries production (to increase hospital financing from the state)
  - Health improvements to the patient
  - Maximize surgeons satisfaction
  - Comply with the goals established by Sistema Integrado de Gestão de Inscritos para Cirurgia (SIGIC)

THIS TALK: year 0

MOTIVATION

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Continuously increasing complexity of health care organizations

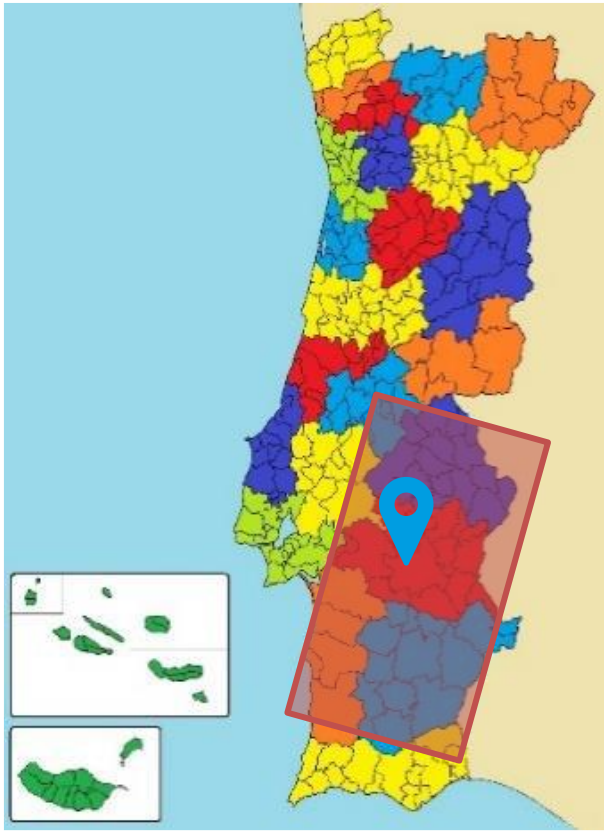
- Aging population
- Increasing demand
- New and expensive technologies

Operating rooms are the main center of costs and revenues at an hospital

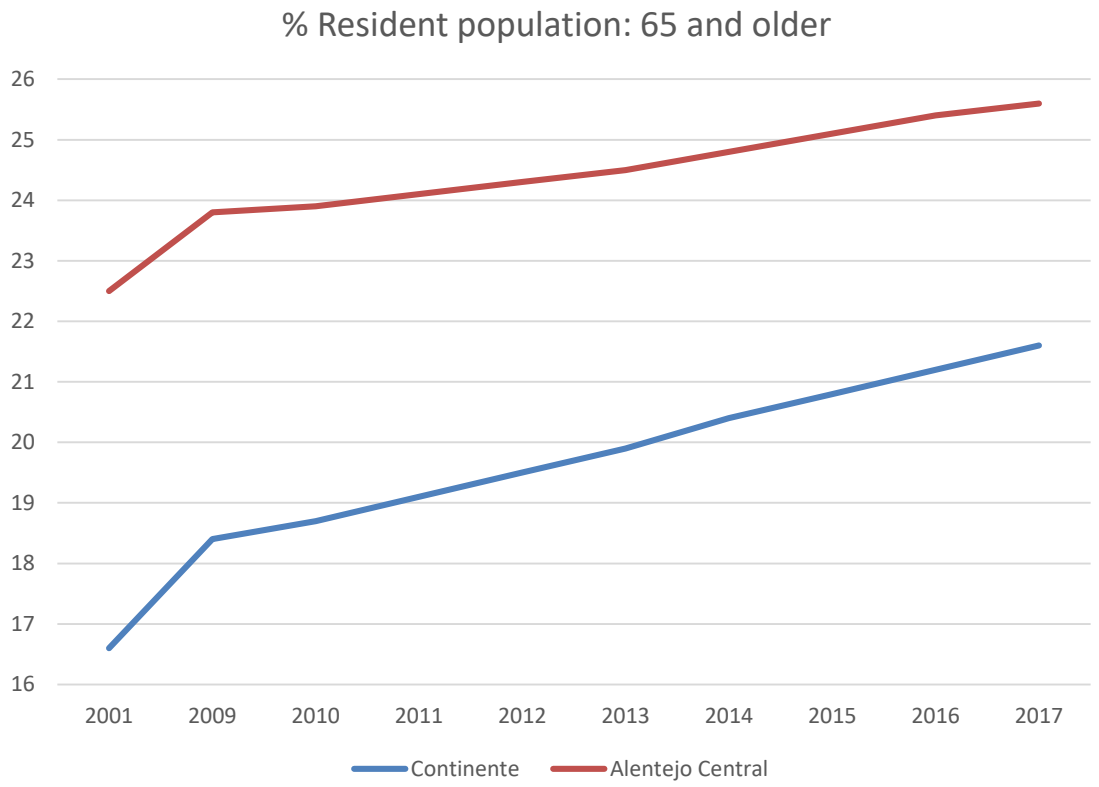
Coordination of scarce resources

- Lack of surgeons
- Lack of anesthesiologists
- Lack of beds

CASE STUDY



Influence area of
the hospital
(325.237 people)



PORDATA
Base de Dados Portugal Contemporâneo

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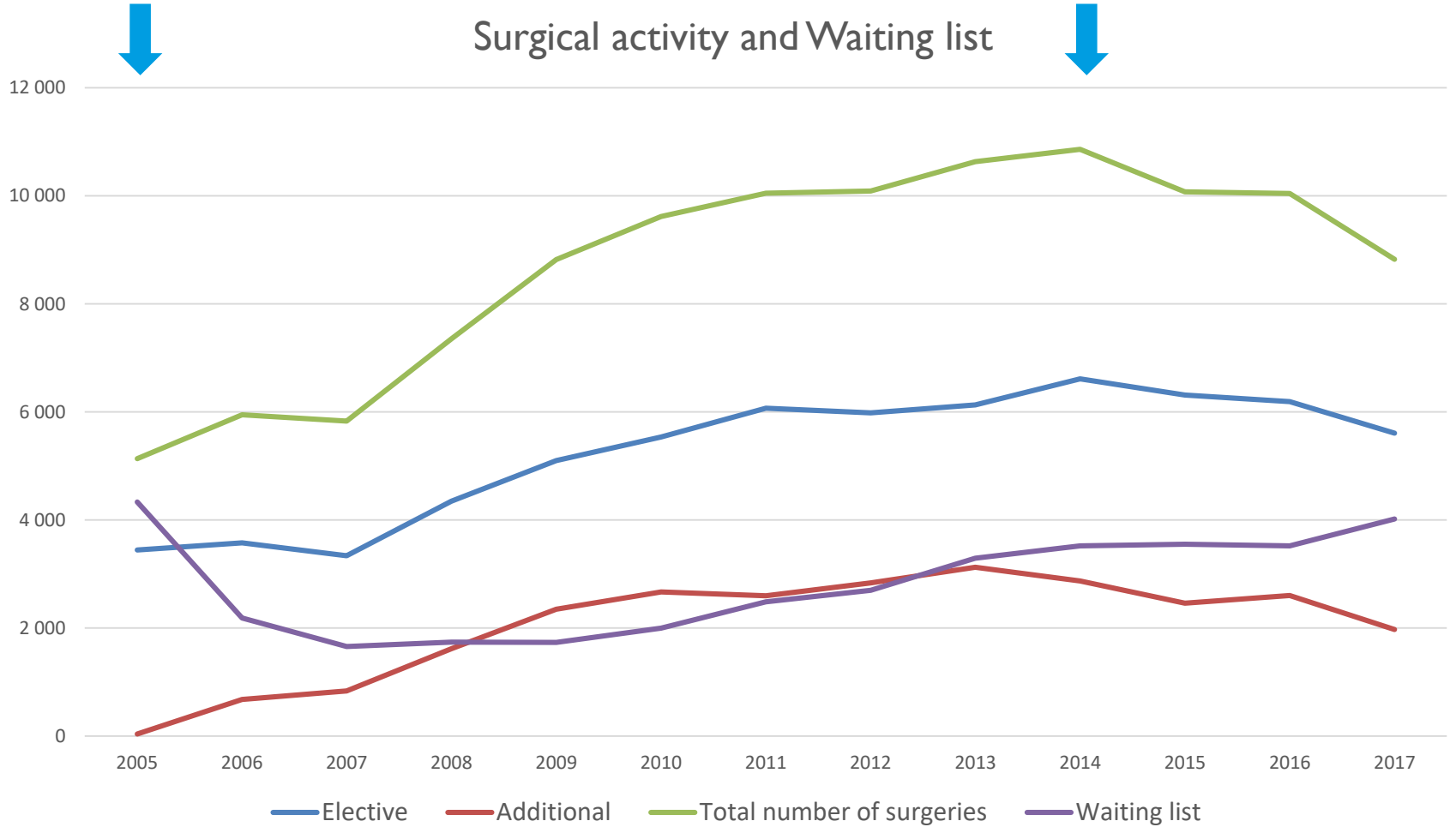
CASE STUDY


Surgical activity and Waiting list
12 000
10 000
8 000
6 000
4 000
2 000
0
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
Elective
Additional
Total number of surgeries
Waiting list

CASE STUDY (WL 2018 Dec 28)

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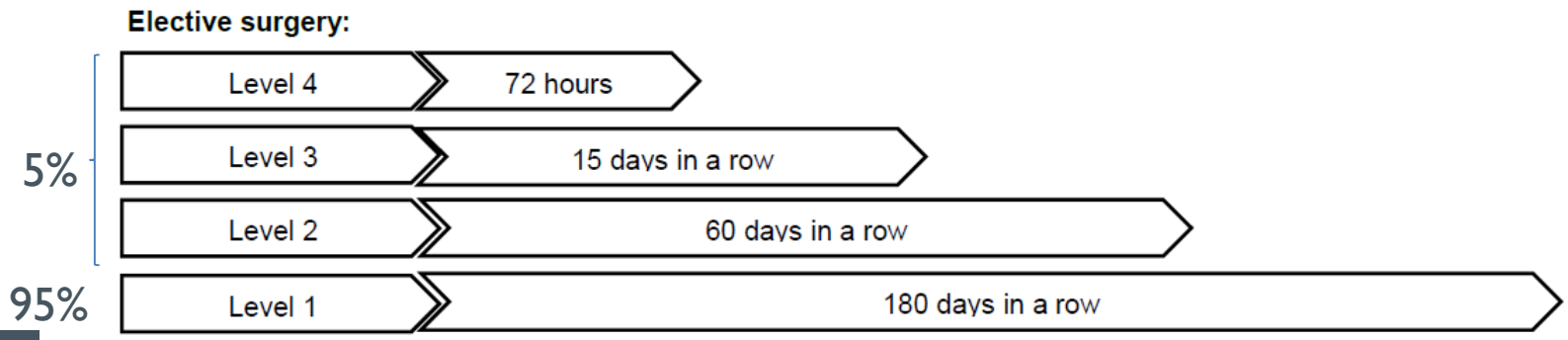
Specialty	Patients		WT ≤180 days		WT > 180		WT 181-270 days		WT 271-260 days		WT > 360 days		Surgeons
	#	%	#	%	#	%	#	%	#	%	#	%	
General	1043	36.5	745	71.4	298	28.6	91	8.7	55	5.3	151	14.5	14
Plastic	295	10.3	292	99.0	3	1.0	3	1.0	0	0	0	0	2
Stomatology	14	0.5	9	64.3	5	35.7	2	14.3	1	7.1	2	14.3	2
Ophthalmology	684	24.0	606	88.6	78	11.4	39	5.7	12	1.8	19	2.8	10
Orthopedics	240	8.4	204	85.0	36	15.0	18	7.5	7	2.9	11	4.6	5
ORL	226	7.9	104	46.0	122	54.0	21	9.3	7	3.1	94	41.6	4
Pediatric	89	3.1	88	98.9	1	1.1	1	1.1	1	1.1	0	0	2
Urology	265	9.3	117	44.2	148	55.8	20	7.5	22	8.3	106	40.0	4
Total	**2856**	**100**	**2165**	**75.8**	**691**	**24.2**	**195**	**6.8**	**105**	**3.7**	**383**	**13.4**	**43**



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CASE STUDY

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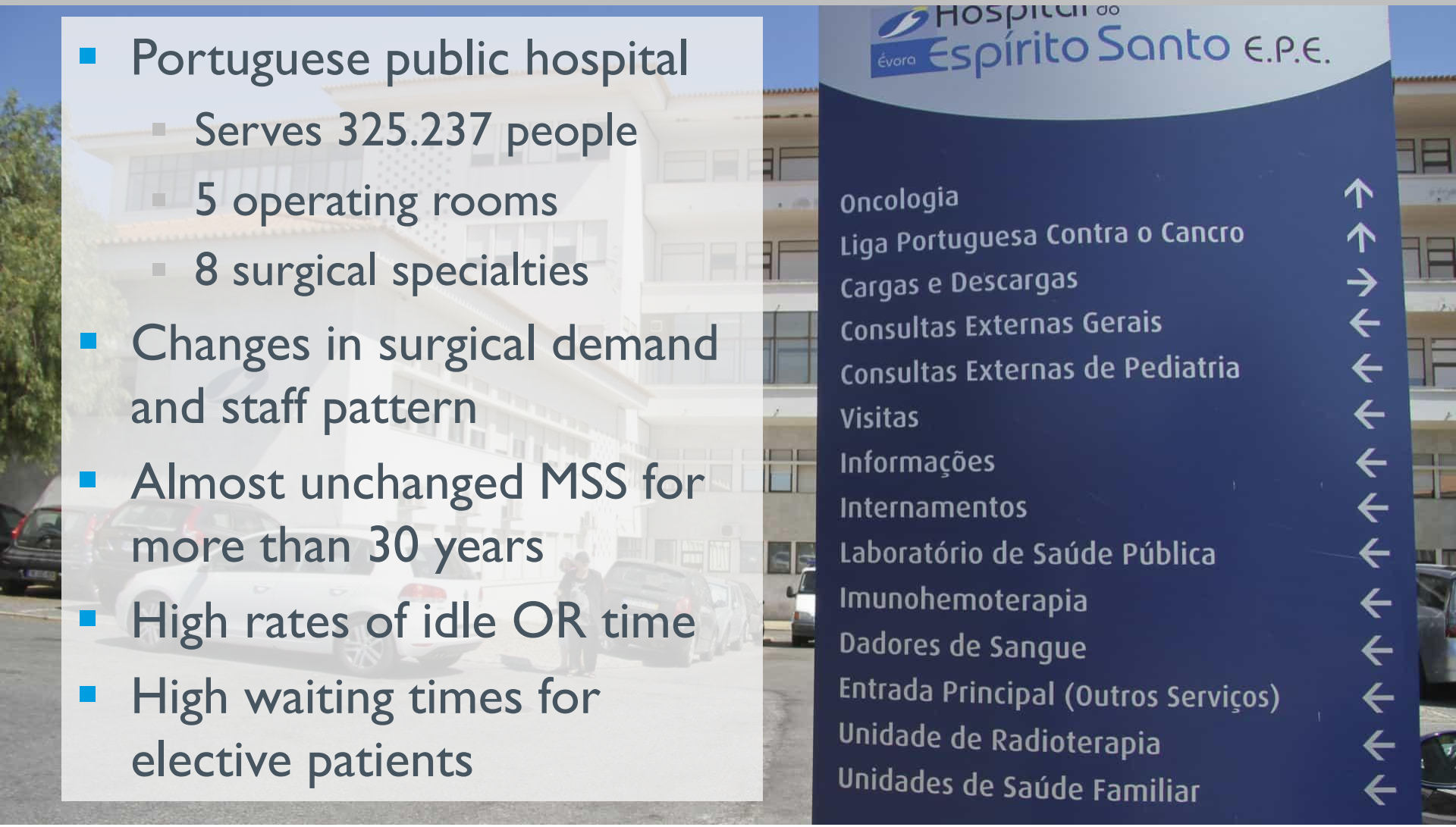
Indicators	OR 1	OR 2	OR 3	OR 4	OR 5	Total
Number of weekly allocated hours	48	48	12	30	36	198
Average weekly number of used hours	31.9	33.6	10	21	2.4	102
Occupancy rate	66.5%	70.0%	83.3%	70.0%	6.7%	51.5%

Bed pool	Specialties	Number of beds
Pre-ward	All specialties	32
Surgery 1	General, plastic, estomatology	47
Surgery 2	General, estomatology, urology	28
Surgery 3	Orthopedic, ophthalmology, ORL	47
Pediatric surgery	Pediatrics	18
Total		172

CASE STUDY

- Portuguese public hospital
  - Serves 325.237 people
  - 5 operating rooms
  - 8 surgical specialties
- Changes in surgical demand and staff pattern
- Almost unchanged MSS for more than 30 years
- High rates of idle OR time
- High waiting times for elective patients



CASE STUDY

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	OR1	OR2	OR3	OR4	OR5
MON	C. Geral	Urologia		Ortopedia	Oftalmologia
	C. Geral	C.Geral Tira I ou Tira II a)			
TUE	C. Geral	C. Geral		Ortopedia	Oftalmologia
	C. Mama	C. Plástica			Oftalmologia
WED	C. Plástica	C. Pediátrica		Ortopedia	Oftalmologia
	C. Ger. Varizes		O.R.L.		
THU	C. Geral	C. Geral		Ortopedia	Oftalmologia
		Urologia	O.R.L.		
FRI	C. Geral	Estomat. [b)]		Ortopedia	Oftalmologia c/ locais
		Implantofix [c)]			

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CASE STUDY

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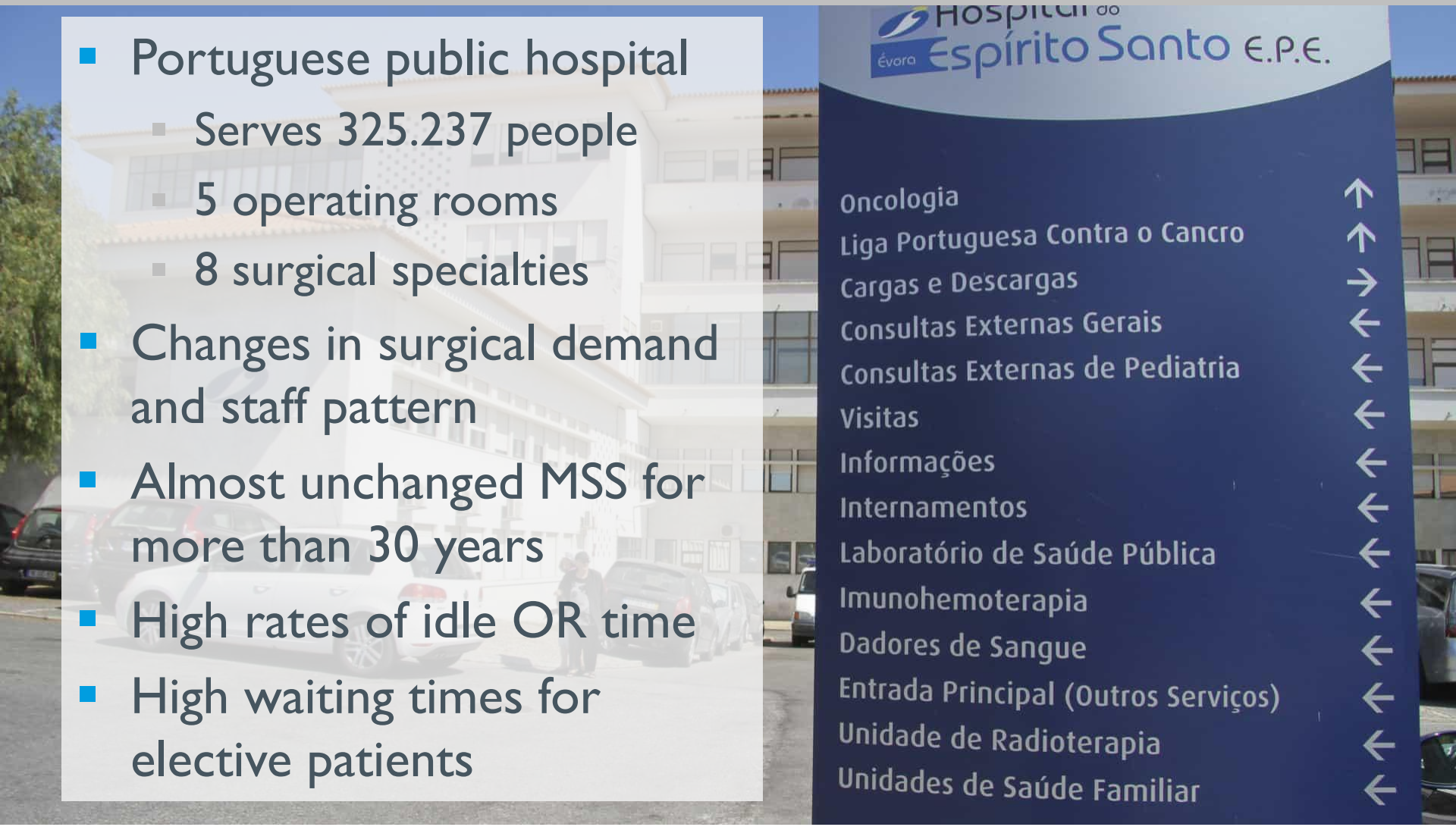


PROBLEM DESCRIPTION

- Capacity planning - MSS
  - Tactical (aggregate) level
- Long planning horizon
- MSS stability
- Max number of slots assigned to each specialty
  - specialty capacity
  - defined by the # doctors and the max workload of each surgeon
  - surgeon workload measured in number of slots
- Up- and downstream capacity

OBJECTIVES

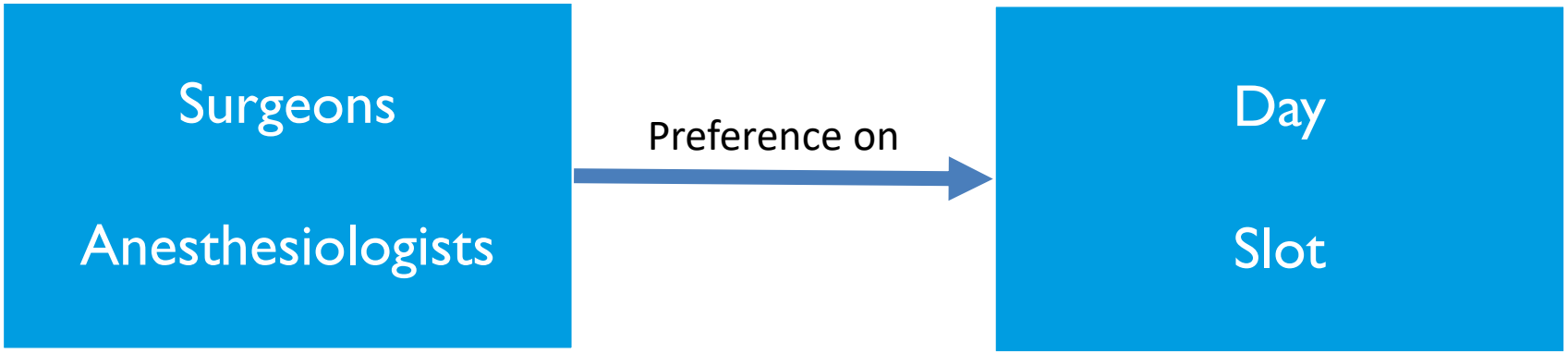
SURGICAL TEAM PREFERENCES

BALANCE SUPPLY AND DEMAND

UP- AND DOWNSTREAM UNITS WORKLOAD

OBJECTIVES

SURGICAL TEAM PREFERENCES



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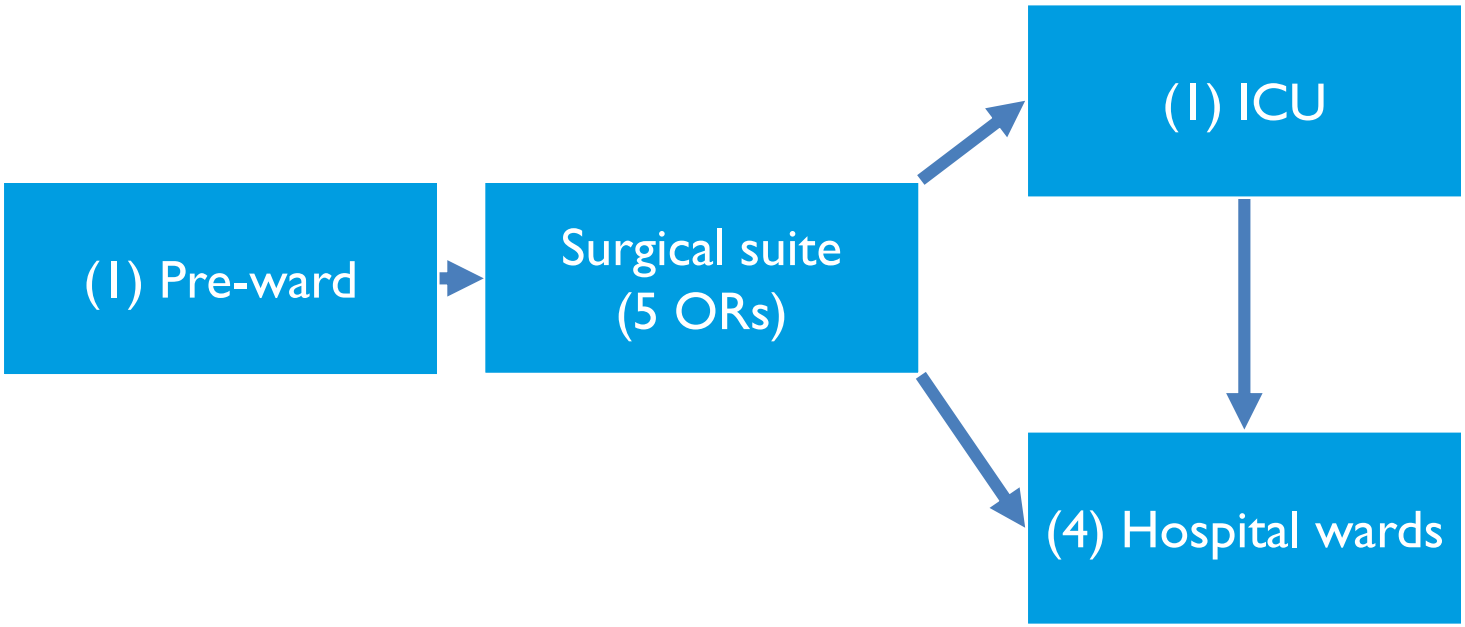
BALANCE SUPPLY AND DEMAND

WL in 28-12-2018

Specialties	% Overall WL length (WL)	% Overall WL duration (WD)	% Allocated blocks (AB)	Difference (WL-AB)	Difference (WD-AB)
General	36.5 %	48.6 %	37.2 %	- 0.7 %	11.4 %
Plastic	10.3 %	8.6 %	6.6 %	3.7 %	2.0 %
Stomatology	0.5 %	0.3 %	0.3 %	0.2 %	0.0 %
Ophtalmology	24.0 %	13.6 %	18.6 %	5.4 %	-5.0 %
Orthopedics	8.4 %	10.0 %	16.3 %	-7.9 %	-6.3 %
ORL	7.9 %	5.8 %	9.2 %	- 1.3 %	-3.4 %
Pediatric	3.1 %	1.3 %	2.4 %	0.7 %	-1.1 %
Urology	9.3 %	11.8 %	9.3 %	0.0 %	2.5 %

OBJECTIVES

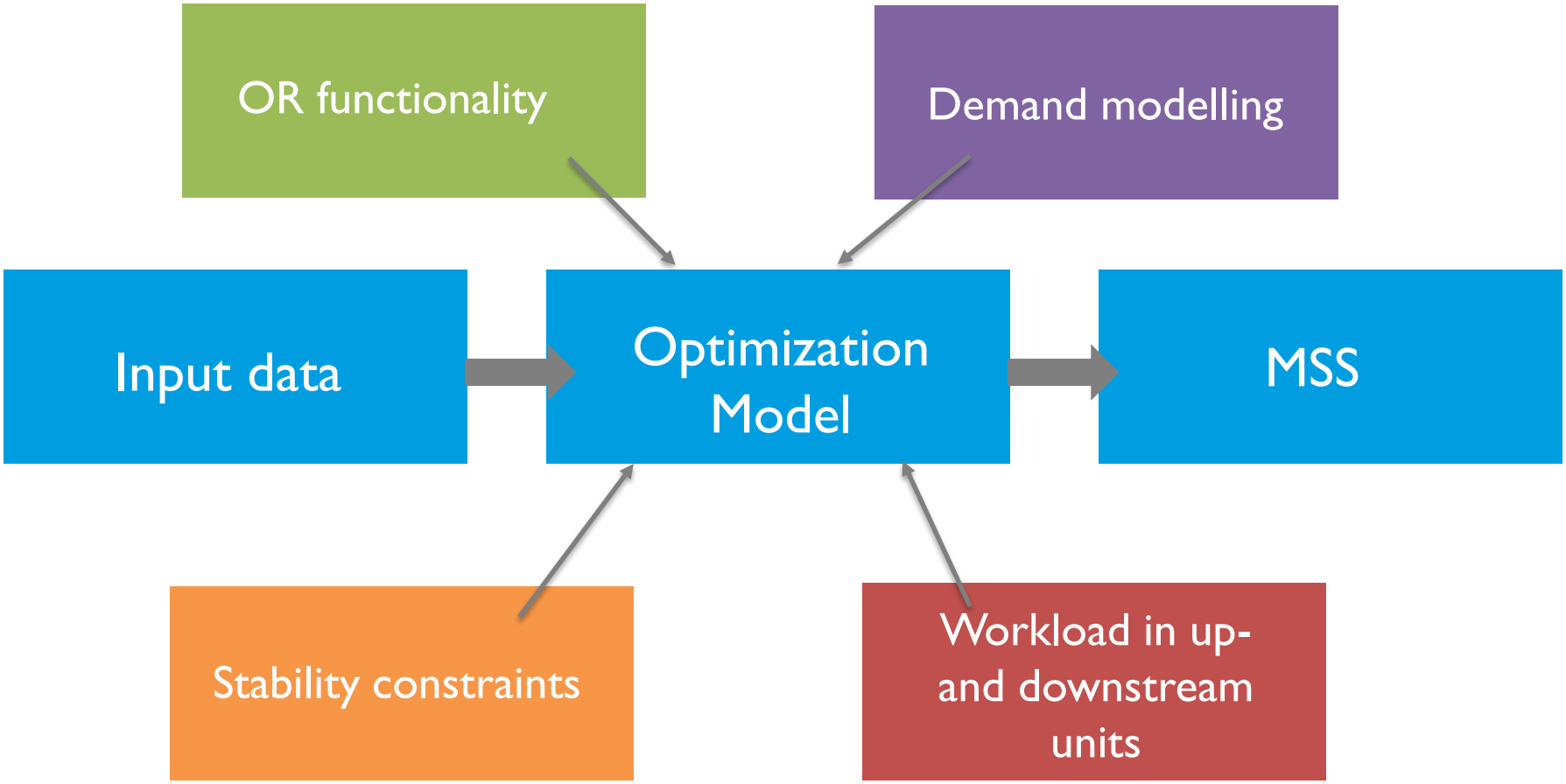
UP- AND DOWNSTREAM UNITS WORKLOAD



LITERATURE REVIEW

Objectives	Surgical team preferences	Balance supply and demand	Up and downstream units workload	Stability/Flexibility of MSS
Banditori et al. (2013)		# PAT WL + DUEDATE		
Abdelrasol et al. (2014)				MOD BLOCK SCHED
Malik et al. (2015)		MIN # PAT WL		
Visintin et al. (2016)				FLEX_ALLOW VAR
Abedini et al. (2017)			PAT FLOW	
Dellaert et al. (2017)			TARGET WORKLOAD	
Penn et al. (2017)	MAX SURG PREF			
Marques et al. (2019)			MIN VARIABILITY	MAX STAB
OUR PROPOSAL	**SURG + ANEST PREF**	**OR TIME**	**TARGET WORK + CAP**	**STAB CONSTRAINT**

METHODOLOGY



MODEL

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Gaps: 0.21-2.34 30min CPU

OR Functionality

$$\sum_{s\in S} x_{swdbr} \le 1 \quad \forall w \in W, d \in D, b \in B, r \in R$$

$$\sum_{s\in S}\sum_{d\in D}\sum_{b\in B}\sum_{r\in R} x_{swdbr} \le slots_w \quad \forall w \in W$$

$$\delta^{surg}\sum_{r\in R} x_{swdbr} \le a^{surg}_{swdb} \quad \forall s \in S, w \in W, d \in D, b \in B$$

$$\delta^{surg}\sum_{b\in B}\sum_{r\in R} x_{swdbr} \le \sum_{i\in I_s} a^{surgD}_{iwd} \quad \forall s \in S, w \in W, d \in D$$

$$\delta^{surg}\sum_{d\in D}\sum_{b\in B}\sum_{r\in R} x_{swdbr} \le \sum_{i\in I_s} ww^{surg}_i \quad \forall s \in S, w \in W$$

$$\delta^{anest}\sum_{s\in S}\sum_{r\in R} x_{swdbr} \le a^{anest}_{wdb} \quad \forall w \in W, d \in D, b \in B$$

$$\delta^{anest}\sum_{s\in S}\sum_{b\in B}\sum_{r\in R} x_{swdbr} \le \sum_{a\in A} a^{anestD}_{awd} \quad \forall w \in W, d \in D$$

$$\delta^{anest}\sum_{s\in S}\sum_{d\in D}\sum_{b\in B}\sum_{r\in R} x_{swdbr} \le \sum_{a\in A} ww^{anest}_a \quad \forall w \in W$$

$$\sum_{w\in W_m}\sum_{d\in D}\sum_{b\in B}\sum_{r\in R} x_{swdbr} \ge mw_{sm} \quad \forall s \in S, m \in M$$

Demand modelling

$$p_{sw} = p_{s,w-1} + ent_{s,w-1} - \sum_{d\in D}\sum_{b\in B}\sum_{r\in R} \lambda_s x_{s,w-1,d,b,r} \quad \forall s \in S, w \in W \setminus \{1\}$$

$$p_{s1} = inic_s \quad \forall s \in S$$

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

$$\theta\sum_{d\in D}\sum_{b\in B}\sum_{r\in R} x_{swdbr} + t^-_{sw} - t^+_{sw} = t_{sw} \quad \forall s \in S, w \in W$$

Input data

Stability

$$|x_{swdbr} - x_{sw_{1m}dbr}| = y_{swdbr} \quad \forall s \in S, w \in W_m \setminus \{w_{1m}\}, m \in M, d \in D, b \in B, r \in R$$

$$\sum_{s\in S}\sum_{d\in D}\sum_{b\in B}\sum_{r\in R} y_{swdbr} \le \Delta_w \quad \forall w \in W$$

$$|x_{swdbr} - x_{sldbr}| = j_{swdbr} \quad \forall s \in S, w \in W_m, m \in M \setminus \{1\}, l = w - \sum_{g<m} |W_g|, d \in D, b \in B, r \in R$$

$$\sum_{s\in S}\sum_{w\in W_m}\sum_{d\in D}\sum_{b\in B}\sum_{r\in R} j_{swdbr} \le \Delta_m \quad \forall m \in M$$

Up and downstream units

$$0 \le f_{zk} - \sum_{s\in S_z}\sum_{b\in B}\sum_{r\in R}\sum_{l=0}^{n_{zs}-1} \lambda_s e_{zsk} x_{s,w,d\pm l,b,r} \le 1 \quad \forall z \in Z, k \in K : k \to (w,d), w \in W, d \in D$$

$$f_{zk} + u^-_{zk} - u^+_{zk} = u_{zk} \quad \forall z \in Z, k \in K$$

$$u^+_{zk} \le c_{zk} - u_{zk} \quad \forall z \in Z, k \in K$$

$$u^-_{zk} \le G\left(1 - v^u_{zk}\right) \quad \forall z \in Z, k \in K$$

$$u^+_{zk} \le G\, v^u_{zk} \quad \forall z \in Z, k \in K$$

	OR1	OR2	OR3	OR4	OR5
MON	C. Geral	Urologia	Urgência	Ortopedia	Oftalmologia
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TUE	C. Geral	C. Geral	Urgência	Ortopedia	Oftalmologia
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	C. Ger. Varizes	Urgência	O.R.L.		
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	Urgência	Urologia	O.R.L.		
FRI	C. Geral	Estomat. b) Implantofix c)	Urgência	Ortopedia	Oftalmologia c/ locais

RESULTS

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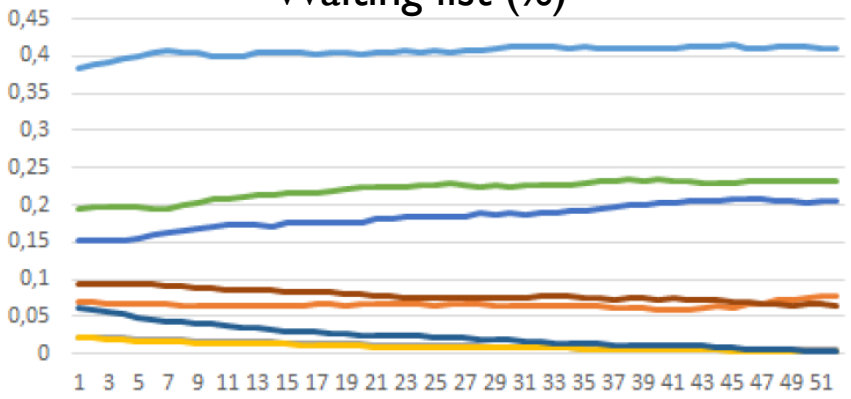
- Real Capacity

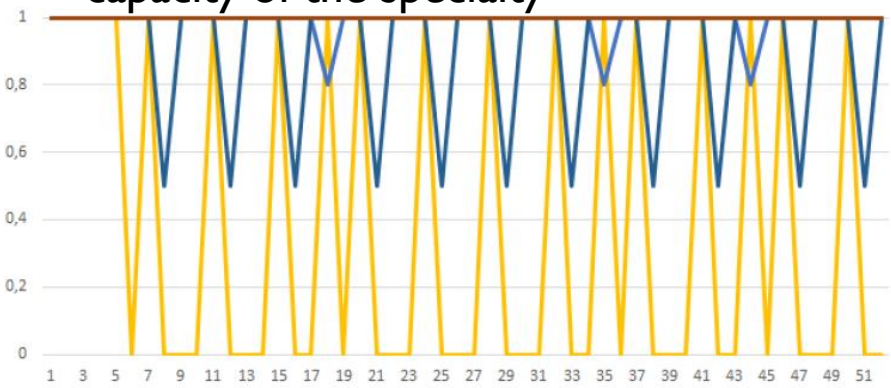
Low demand

High demand, short surgeries, high resources consumption

Waiting list (%)



Specialty capacity (%), compared to the max capacity of the specialty

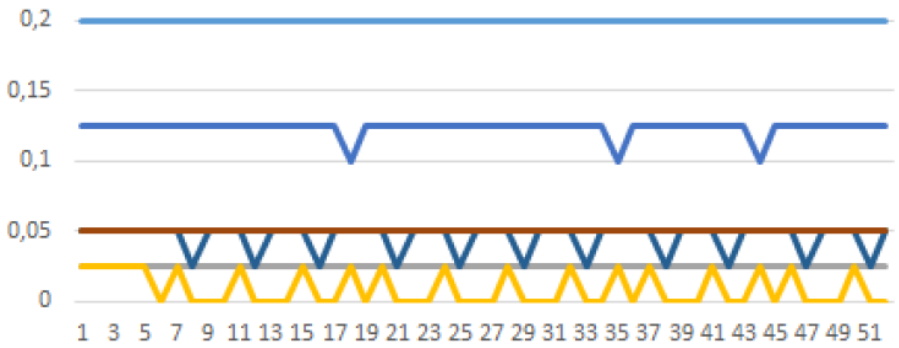


Specialties at max capacity

Low compliance supply vs demand

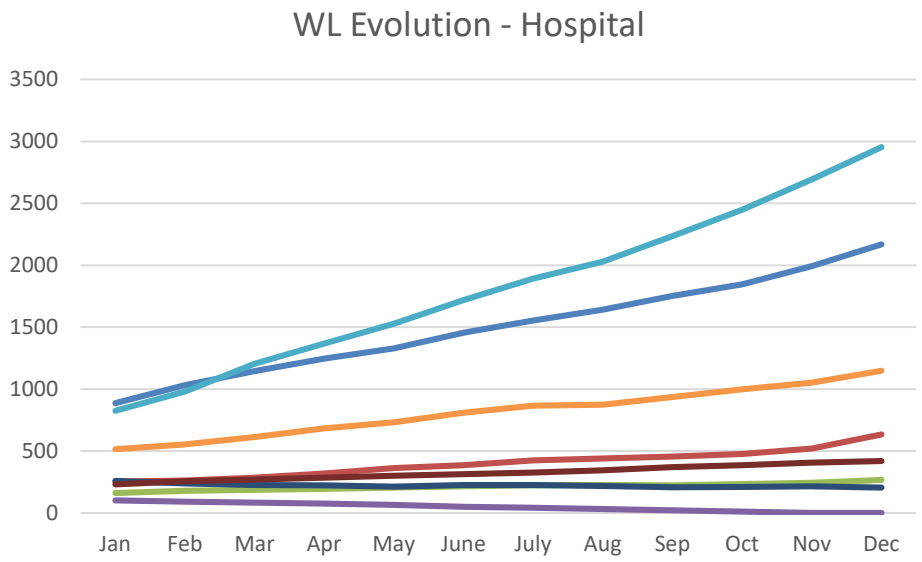
Only 55% slots assigned

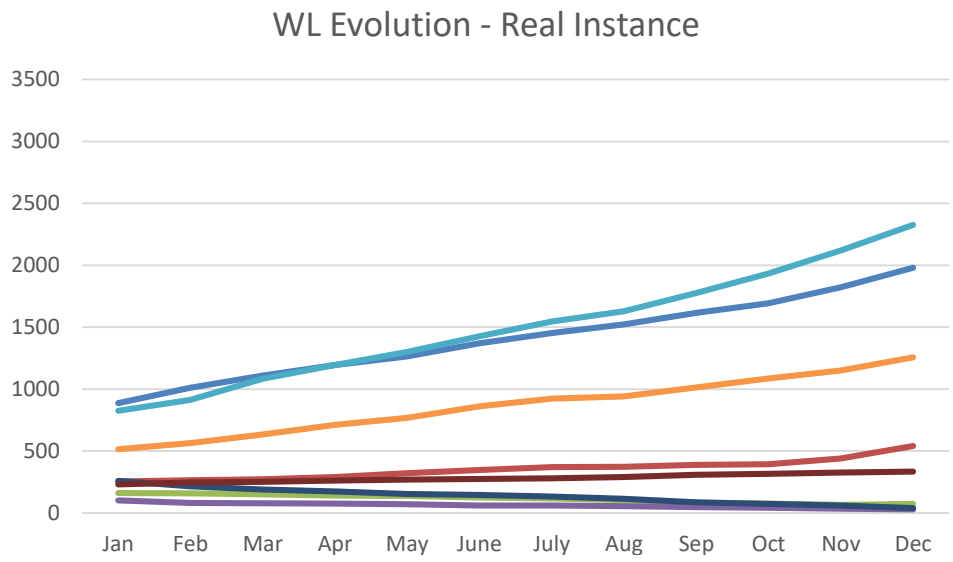
Allocated slots (%): percentage of total available slots



RESULTS

- Real Capacity: Evolution of the waiting list





✓ Capacity constraints

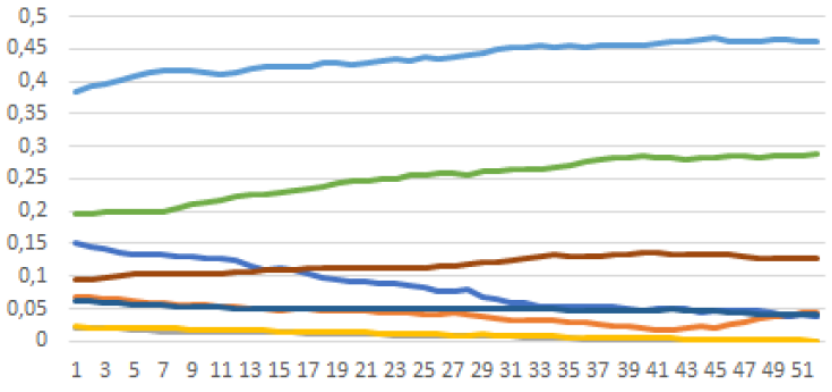
✓ Better management of low resources

RESULTS

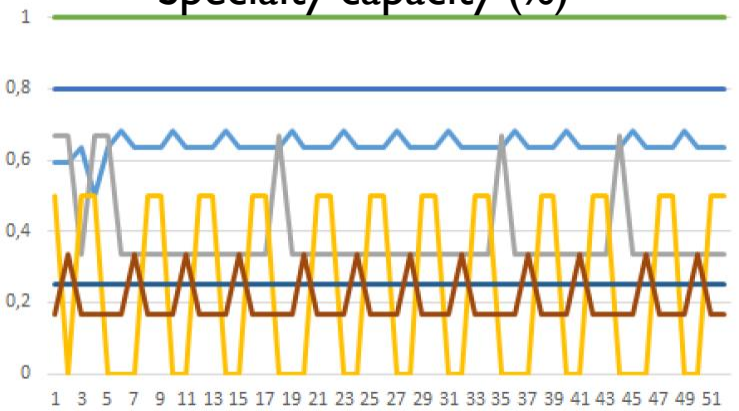
High demand, long surgeries, 5 surgeons – difficult to match demand

- **Increased Capacity** (Real Capacity + 2 slots per doctor)

Waiting list (%)



Specialty capacity (%)

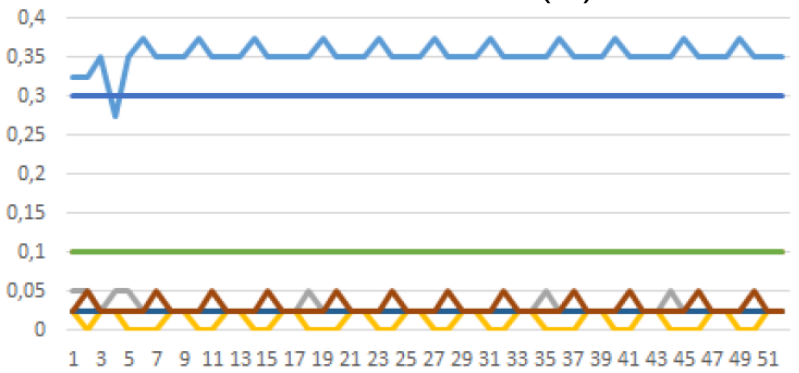


More flexibility regarding capacity

Better compliance supply vs demand

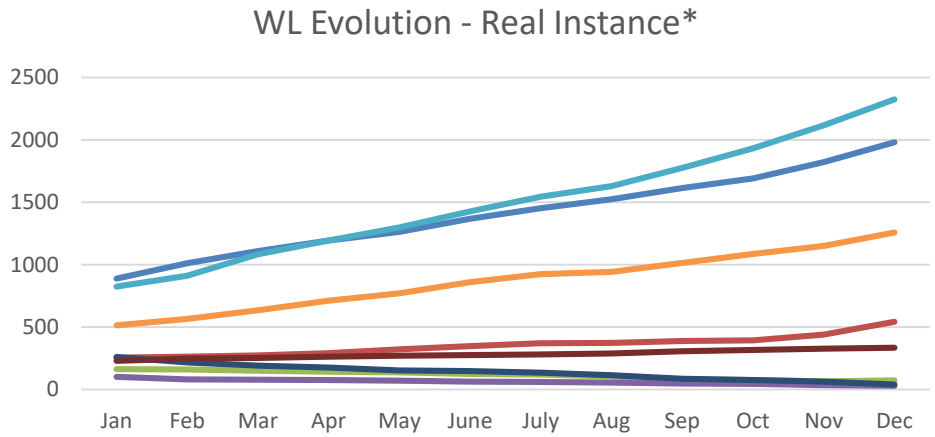
About 95% slots assigned

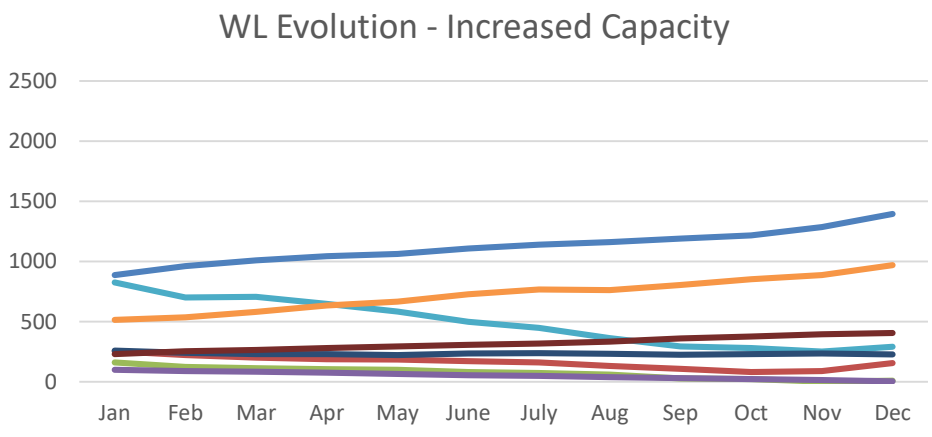
Allocated slots (%)



RESULTS

- Increased Capacity: Evolution of the waiting list





* Assuming 100% utilization

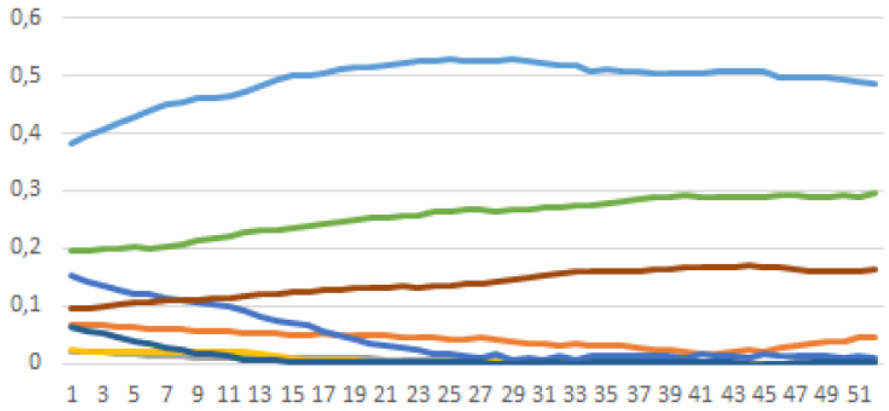
- ✓ WL reduces for large demand specialties
- ✓ Ophthalmology, General surgery, Orthopedics (lower decrease)

Specialty	General	Plastic	Pediatric	Stomathology	Ophtalmology	Orthopedics	ORL	Urology
#Doctors	14	2	2	2	10	5	4	4

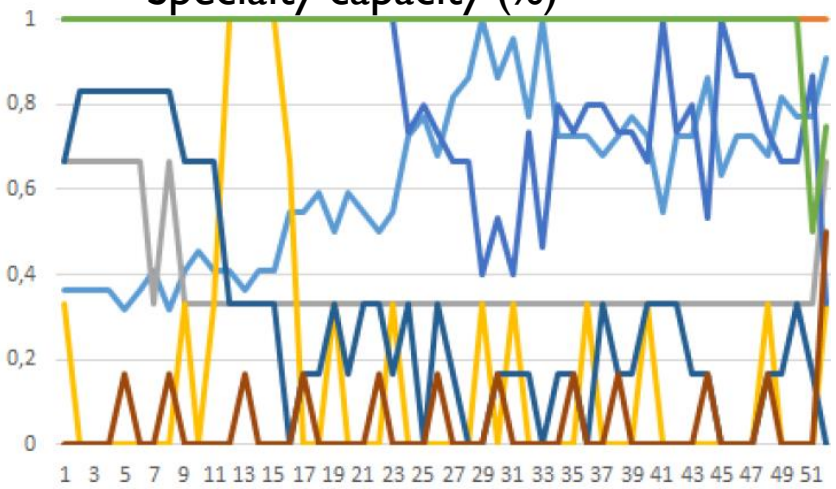
RESULTS

- Increased Capacity + No Stability Constraints

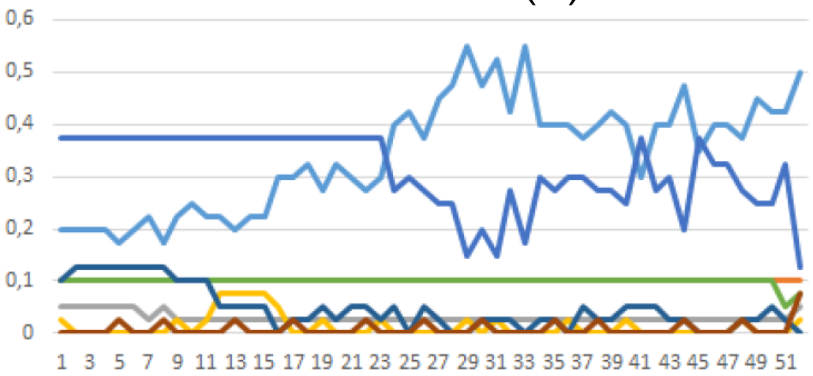
Waiting list (%)



Specialty capacity (%)



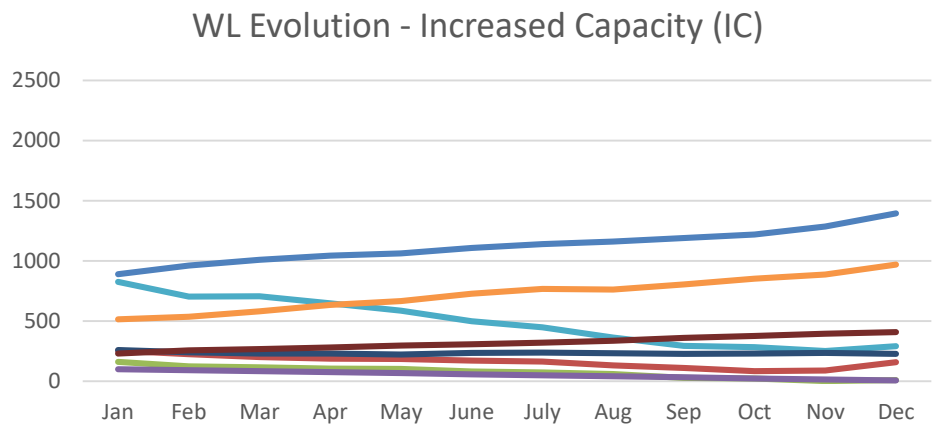
Allocated slots (%)

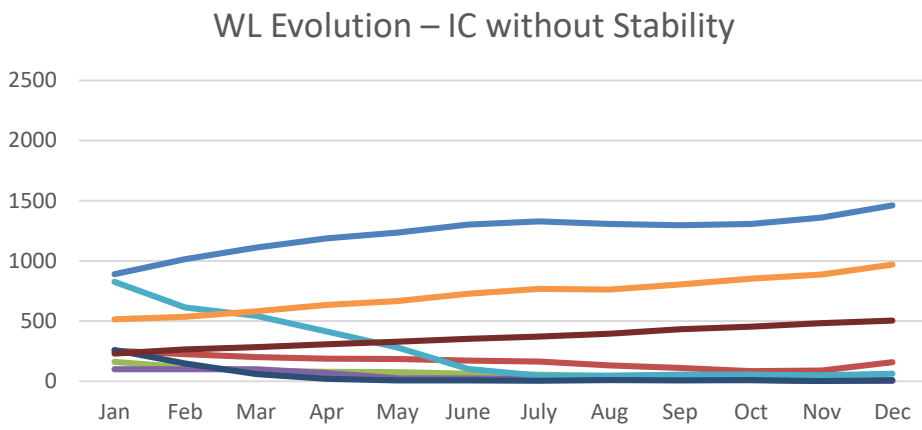


- More flexibility to chase demand
- Potential to schedule more patients
- About 95% slots assigned
- Doctors not satisfied

RESULTS

- No Stability Constraints: Evolution of the waiting list





- ✓ WL reduces for most specialties
- ✓ Except General surgery and Orthopedics (already reduced in IC) and Urology (4 surgeons)
- ✓ Schedules more patients
- ✓ Tradeoff nb of surgeries vs surgeons satisfaction

CONCLUSIONS

Static & old MSS

Inefficient use of OR

Long WT

Major bottleneck: workforce (mainly surgeons)

Stability constraints and workload capacity influence the compliance with the dynamic demand

FUTURE WORK

Predictive model for demand forecast

Sensitivity analysis on stability parameters

Consistent models for stakeholders' preferences

Simulation model for an evaluation of the model at disaggregated level

Impact of preferences in OR utilization

Reallocating operating room time: a Portuguese case

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Thank you!

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PORTUGAL 2020

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Fundo Europeu de Desenvolvimento Regional