Quality Improvement Report

A new era of quality improvement: Creating a digital twin of the radiology department to drive efficiencies in operations and workflow

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Introduction: The past and future of Quality Improvement

PAST

- Classic methodologies: Lean, Six-sigma
- Ad-hoc projects with defined periods for measurement, analysis, intervention
- Manual data collection
- Optimizes one objective; ignores negative second order effects
- Quickly outdated with new circumstances

FUTURE

- Digital Twin: a model of a physical system in software
- Automatic, real-time data collection
- Continuously evolving via new data assimilation
- Allows for simulation to discover optimal solution with constraints
- Can be used to answer many questions and perform a wide range of analysis

Case study: Optimizing scheduled slot size based on true exam duration

- Objective 1: Determine an achievable slot size for the top MRI exam ranked by cumulative exam duration
- Objective 2: Simulate impact of intervention (change in slot size) on net scanner time saved, exam volume, and exam delays

Method (1/2)

- We used commercially available software (Quantivly, Inc) that cleans and harmonizes DICOM metadata, extracting key concepts – e.g. true acquisition and examination duration – to create a new ontology for radiology operations

- The database was fully query-able (via SQL and GraphQL), allowing us to slice the data to perform the analysis

Method (2/2)

- MRI exams were sorted by cumulative exam duration.
- We plotted the distribution of exam duration for top 4 exams along with the acquisition timeline for the ten longest instances of the top exam
- We simulated the change in patient volume, number of delays, and median exam delay with reduced slot size

Results (1/4)

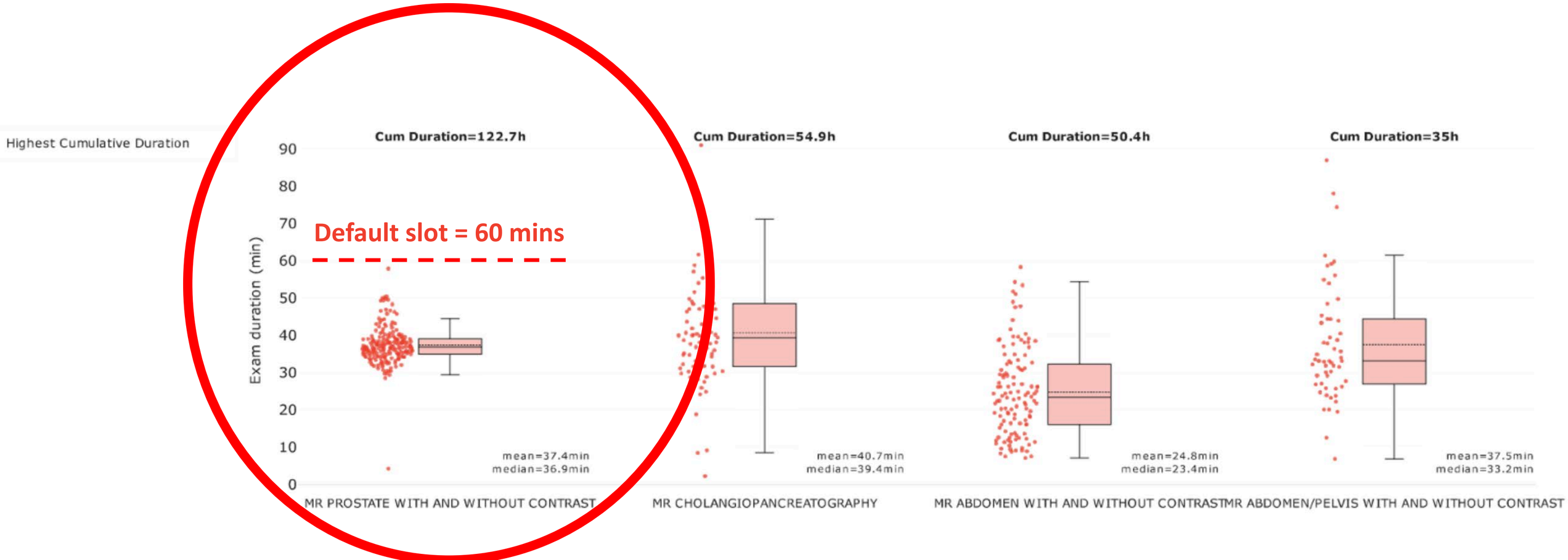
- The top exam in the “body” section was **“MR PROSTATE WITH AND WITHOUT CONTRAST”** by a wide margin - **123 hours** vs. 50.4 hours for the second highest

Exam details

protocol_name	n_exams	avg_duration (min)	cumulative_duration (h) ↓	avg_efficiency	avg_acq_per_exam
MR PROSTATE WITH AND WITHOUT CONTRAST	197	37.4	123	0.805	9.18
MR CHOLANGIOPANCREATOGRAPHY	81	40.7	54.9	0.395	12.0
MR ABDOMEN WITH AND WITHOUT CONTRAST	121	24.8	50.0	0.429	9.12
MR ABDOMEN/PELVIS WITH AND WITHOUT CONTRAST	56	37.5	35.0	0.421	14.8

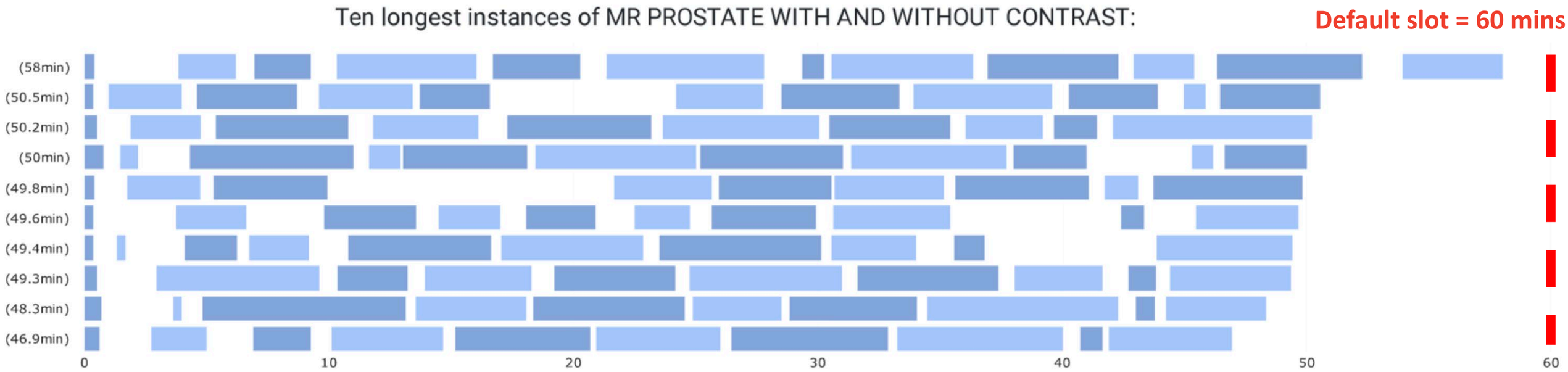
Results (2/4)

- Despite a default slot size of 60 mins, most exam durations were **less than 50 mins**.



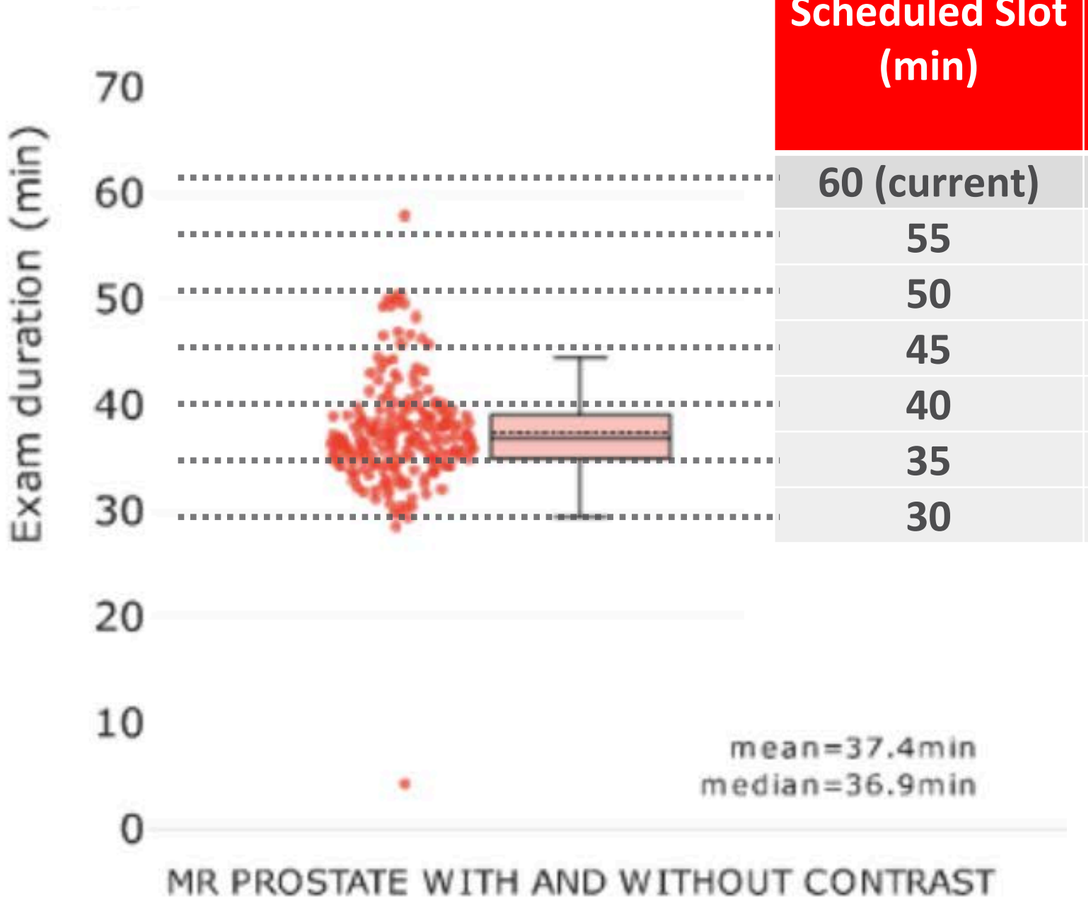
Results (3/4)

- Even the longest exams were performed **well under the scheduled 60 min slot size**



Results (4/4)

- We can simulate the impact of various slot sizes in-silico



Scheduled Slot (min)	Hours Saved (over 90 days)	Additional patients (per week)	Total exams delayed (90 days)	Median Delay (min)
60 (current)	N/A	N/A	0	0
55	16.4	1	1	3
50	32.8	3	3	0.5
45	49.3	5	15	4.3
40	65.7	8	37	3.6
35	82.1	11	142	3.1
30	98.5	15	192	6.9

Discussion

- The default slot size of 60 mins with no delays did not represent the best trade-off in terms of patient access
- We simulated the impact of reducing the slot size for the top body exam, uncovering the potential to create slots for 5 additional patients per week, reducing wait times, and increasing department revenue.
- Future work: 1) Implement a change in our scheduling system to reduce prostate slot size and 2) further stratify the clinical, technical, and demographic factors that lead to longer exam durations