Data driven optimization and monitoring of MR scheduling

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Background and Motivation

- MR exams must be scheduled in appropriate time slots to maintain operational efficiency.
- Traditional methods of estimating exam durations such as scanner estimates of active scan time fail to account for the inherent variability in the process.
- Comprehensive and robust quantitative information on MR exam durations would aid in optimizing MR scheduling.

Variability in exam duration for consecutive screening breast exams:

Exam 1 – Exam duration: 27:30; Active scan time (w/o) repeat: 15:20
- Inter-sequence time

Exam 2 – Exam duration: 19:07; Active scan time: 14:56

Δ Exam duration = 8:27
Objective

- Use historical performed exam duration data to:
  1. Identify schedule inefficiencies
  2. Design appropriate scheduling interventions
  3. Assess the impact of interventions on operational efficiency
Methods: Exam Duration Data

- Exam durations were extracted from Quantivly, a software platform that harmonizes DICOM metadata in an easily retrievable and vendor agnostic format.
- Exam duration data was merged with RIS data to select outpatient exams only.
- High volume outpatient exams were reviewed for inefficiencies.

Exam A; Vendor A

Exam B; Vendor B

DICOM Q/R

Quantivly

Public/Private DICOM metadata → Multi-stage data harmonization/ontology mapping → Vendor agnostic DB storage

Web Interface

API
Available time slots: 15, 30, 45, 60 minutes
A 10 minute buffer is desired to turn the room around between patients
Each exam is considered too short, ideal, acceptable, or too long based on the assigned time slot and buffer time

Methods: Exam Duration Fit

- **Too short**: Exam would be more appropriate in a 15 or 30 minute slot
- **Ideal**: Exam finishes with at least 10 minute buffer without being under time
- **Acceptable**: Exam finishes within scheduled timeslot without a full 10 minute buffer
- **Too long**: Exam was longer than the scheduled time slot
Target Exams– Prostate and MRCP

<table>
<thead>
<tr>
<th>Inefficiency</th>
<th>Prostate w/wo contrast (60 min.)</th>
<th>MRCP w/wo contrast (30 min.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Substantial difference (~9 min) in median exam duration between 3T scanners due to scanner technology</td>
<td></td>
<td>• Majority of exams acceptable or over time</td>
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<td></td>
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<td>• Substantial variability in exam duration likely due to variation in scanner platforms and respiratory motion management</td>
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</tbody>
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| Intervention | | |
|--------------| | |
| • Trial preferential scheduling to more efficient scanner (10/1/21-3/15/22) | | • Extend scheduled time slot from 30min. to 45 min. (effective 3/15/22) |
| • Reduce scheduled time slot from 60. to 45 min. (effective 3/15/22) | | |

| Assessment | | |
|------------| | |
| • Percentage of exams on preferred scanner | | • Change in on-time metrics |
| • Change in on time metrics | | |

Net time made available on outpatient schedule
Results: Pre/Post Schedule Change

Pre-schedule change

Prostate w/o contrast - 60 min. slot
N=798; 10/01/2021 - 03/14-2022

Post-schedule change

Prostate w/o contrast - 45 min. slot
N=944; 03/16/2022 - 09/29-2022

MRCP w/o contrast - 30 min. slot
N=851; 10/01/2021 - 03/14-2022

MRCP w/o contrast - 45 min. slot
N=851; 03/16/2022 - 09/29-2022
Results: Key Metrics

Prostate w/wo contrast

- 95% exams on preferred scanner before intervention; 92% after intervention
- Ideal exams: 11% → 82%
- Ideal or acceptable exams: 12% → 98%

MRCP w/wo contrast

- Ideal exams: 9% → 78%
- Ideal or acceptable exams: 74% → 88%

Net Impact

- 73 net hours made available on outpatient schedule after interventions
  - 2.6 hours/week
  - 133 hours/year (extrapolated)
Discussion

• Quantitative analysis of historical exam durations can be used to streamline MR operations
  – More exams finish on time → improved patient/staff satisfaction
  – Net scheduled duration decreased → potential increase in volume

• Automated analysis provides critical information on the variability in exam durations that cannot be practically obtained otherwise
Future Directions

• Repeat analysis with other exams
• Further analyze duration data to identify root causes of variability (scanner, technologist, patient etc.)
• Investigate other possible interventions beyond scheduling adjustments such as protocol changes and additional staff training