Considering No-shows And Procedure Time Variability When Scheduling Endoscopy Patients

Karmel Shehadeh
Jacob Kurlander, MD
Amy Cohn, PhD
Sameer Saini, MD

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Team Recognition

• Systems Concepts for the Optimization and Personalization of Endoscopy Scheduling (SCOPES) team
  – Amy Cohn, Dr. Kurlander and Dr. Saini
  – All CHEPS students who have contributed to SCOPES
Presentation Outline

• Background
• Schedule quality analysis
• Key messages
• Future directions
Presentation Outline

• **Background**
  • Schedule quality analysis
  • Key messages
  • Future directions
Endoscopy Unit

• Outpatient Procedure Center (OPC)

• Conducting screening and surveillance procedures for diseases affecting the digestive system
  – abdominal pain, colitis, constipation, etc.

• Encountering exponentially increasing demand in a resource-constrained setting
  – 7.25 million procedures in 2010

Colonoscopy Procedure

- Screening test for **Colorectal Cancer** (CRC)
  - 2\textsuperscript{nd} leading cause of cancer-related death in the US\textsuperscript{2}

- Enables a gastroenterologist to evaluate the inside of the large intestine (rectum and colon)
  - Identify existing cancer, prompting treatment
  - Prevent future cancer (**polyps**)
Colonoscopy Scheduling

- Many challenges in OPC scheduling
- Scheduling colonoscopy yields an added challenge due to the **bimodal duration** structure

<table>
<thead>
<tr>
<th>Duration</th>
<th>Prep Quality</th>
<th>Health Conditions</th>
<th>No. of Polyps</th>
</tr>
</thead>
<tbody>
<tr>
<td>Short (30 min)</td>
<td>Adequate</td>
<td>Good</td>
<td>Low</td>
</tr>
<tr>
<td>Long (90 min)</td>
<td>Poor</td>
<td>Poor</td>
<td>High</td>
</tr>
</tbody>
</table>

* Note: also for some cases procedure is not performed
Importance?

- **Better Schedule**
  - Less provider fatigue
  - More efficient performance
- **Less Waiting**
  - Better experience
  - Fewer cancelation
- **Better Outcome!**
Presentation Outline

- Background
- **Schedule quality analysis**
- Key messages
- Future directions
Monte Carlo Simulation (MCS)

• Identify scheduling policies while
  1. Considering the **unique and bimodal** duration structure

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⇒ Patient $i$ has probability of $p_i$ being a 30 min and $1 - p_i$ of being 90 min procedure
Monte Carlo Simulation (MCS)

• Identify scheduling policies while
  1. Considering the unique and bimodal duration structure
  2. Considering no-shows and the effect of delays

• Evaluate each policy's performance under potentially conflicting metrics
  – Overtime, idle time, waiting time, no. of cancelled procedures
MCS: Tested Policies

Duration Policies

– Fixed
  • Every patient gets 60 minutes

– Predicted duration (PD)
  • $P(90 \text{ min}) = p_i$
  • $P(30 \text{ min}) = 1 - p_i$

– Expected duration (ED)
  • Weighted average

Order Policies

– Random
  • Any order

– Shortest colonoscopy first
  • All 30 min procedures first

– Longest colonoscopy first
  • All 90 min procedures first
**Input**: Set of polices

**Output**: Performance metrics

1. for each policy do
2.     for d=1:days do
3.         Assign patient a procedure duration type
4.         Policy dictates order and duration
5.         Process the patients throughout the day (actual schedule)
6.         Calculate the metrics for the day
7.     end
8.     Calculate the average of metrics over all simulation days for this policy
9. end
10. return Averages of metrics values over all days for each policy
11. Compare across policies

*Figure 1: Monte Carlo simulation logic*
MCS: Characteristics

- Single provider
- Provider and room are immediately available
- 18% no-shows rate
- $N$ procedures

Number of long procedures: $N^l$
- $P(90 \text{ min}) = p$
- Cannot wait more than 60 minutes with high probability

Number of short procedures: $N - N^l$
- $P(30 \text{ min}) = p$
- Cannot wait more than 60 minutes with low probability

Scenario 1

\( N' = 0.2N, \ p = 0.75, \) Waiting Time

\[
\text{Figure 1: Average waiting time (patient/day)}
\]
Scenario 1

$N^I = 0.2N$, $p = 0.75$, No. of Cancelled procedures

Figure 2: Average number of cancelled procedures (day)
$N' = 0.2N$, $p = 0.75$, Overtime

Figure 3: Average overtime (day)
Scenario 1

$N^I = 0.2N$, $p = 0.75$, Idle Time

Figure 4: Average total idle time (day)
Scenario 2

**Higher no-shows rate?**

\( N' = 0.2N, \ p = 0.75, \ rate = 18\% \)

\( N' = 0.2N, \ p = 0.75, \ rate = 35\% \)

*same performance, lower values*
Scenario 2

Higher no-shows rate?

$N^l = 0.2N, p=0.75, \text{rate}=18\%$

\[ N^l = 0.2N, p=0.75, \text{rate}=35\% \]

*higher values, more variability*
Scenario 3

Lower $p$?

$N' = 0.2N$, $p = 0.75$

$N' = 0.2N$, $p = 0.25$

*performance change, more variability*
Scenario 4

Different population?

$N_l = 0.2N$, $p = 0.75$

$N_l = 0.8N$, $p = 0.75$

Figure 1: Average waiting time (patient/day)

Figure 8: Average waiting time (patient/day)

*performance change*
Outline

• Background
• Schedule quality analysis

• **Key messages**

• Future directions
MCS key messages

• Colonoscopy characteristics determine schedule quality

• Unique, different in nature and potentially different from other OPC

• Policy performance depends on the considered characteristic(s)
Outline

• Background
• Schedule quality analysis
• Key Messages
• **Future Directions**
Future directions

• Continue evaluating different scheduling policies considering **ALL** of the **special characteristics** of colonoscopy procedure

• Monte Carlo simulation

• Sampling techniques to approximate uncertainty

• Stochastic optimization for better insights
Support acknowledgement

• Center for Healthcare Engineering and Patient Safety

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• We also express our gratitude to Dr. Jacob Kurlander, Dr. Sameer Saini and all CHEPS students who have contributed to this project
Questions

THE QUESTION MARK

IS IT ALWAYS SO UNCERTAIN?
I'M SO GLAD YOU ASKED.

RESPECT PUNCTUATION

Karmel S. Shehadeh
Ksheha@umich.edu

Amy Cohn
amycohn@umich.edu


Scenario 2

![Bar chart showing average number of appointments under different appointment order policies.

- Random: PD = 3.2, ED = 2.3, Fixed = 2.7
- Easy colonoscopy first: PD = 4.7, ED = 1.7, Fixed = 2.6
- Complex colonoscopy first: PD = 3.5, ED = 2.7, Fixed = 1.9

Duration policy:
- PD
- ED
- Fixed

Appointment order policy:
- Random
- Easy colonoscopy first
- Complex colonoscopy first]
Scenario 4

$N^l=0.8N$, $p=0.75$, No. of Cancelled procedures