2017 CHEPS Healthcare Executive Summit

CENTER FOR HEALTHCARE ENGINEERING & PATIENT SAFETY
UNIVERSITY OF MICHIGAN

Optimization of Colonoscopy Appointment Scheduling Under Uncertainty

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Problem Statement

Colonoscopy Procedure

- Main screening test for colorectal cancer (CRC), the second leading cause of cancer related deaths in the U.S.
- Carried out by a gastroenterologist in an endoscopy clinic
- Allows for direct visual examination of the colon & rectum
  - Spot existing cancer, prompting treatment
  - Prevent future cancer through the detection and removal of precancerous growth

Challenges to Daily Colonoscopy Scheduling

- Significant variability in procedure duration due to quality of pre-procedure bowel preparation

Prep Quality	Procedure Duration
Good	Short
Poor	Long

- Timing of procedure
- Patient absenteeism, lack of punctuality, and cancellations
- Multiple and conflicting criteria that affect the quality of the schedule
  - Patient access to screening and preferences
  - Patients waiting, provider idle and over times

Research Goals

- Reduce the barriers to efficient and timely CRC screening
- Design appointment schedules that are better tailored toward patient outcomes
- Develop a decision support tool to optimize colonoscopy appointment scheduling
  - A list of daily appointment slots to offer for patients (template)
  - Instructions for scheduling patients (scheduling policies)

Framework

- Use simulation and mathematical programming techniques to analyze and improve the scheduling of colonoscopy patients
- Within a Monte Carlo optimization framework, model the variability in procedure duration based on the likelihood of the duration type
- Analyze the properties of an optimized schedule under different levels of uncertainty

Schedule Optimization Model

Objective

Optimal patient appointment order and times that minimize total expected patient waiting and provider idle and over times

First stage decisions (generate a schedule)

Determine patient appointment order and start times

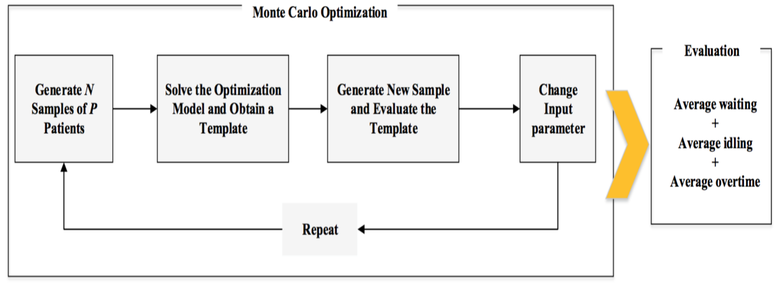
Second stage decisions (actual schedule)

Actual patient arrival and procedure start times

Patient waiting and provider idle and over times

Monte Carlo Optimization

- To study:
  - How the performance of an optimal schedule changes as a function of variation in the prep
  - How the performance of an optimal schedule changes as a function of absenteeism
  - How the performance of an optimal schedule changes as a function of arrival uncertainty



Impact of Variability on Performance

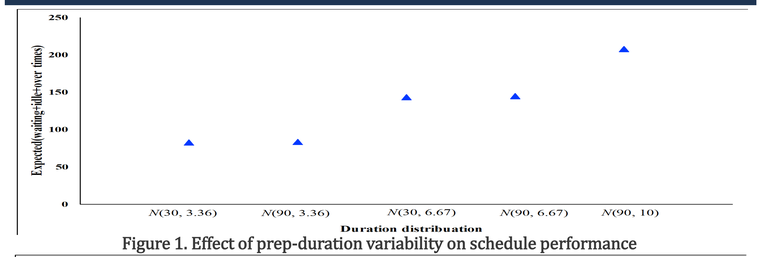


Figure 1. Effect of prep-duration variability on schedule performance

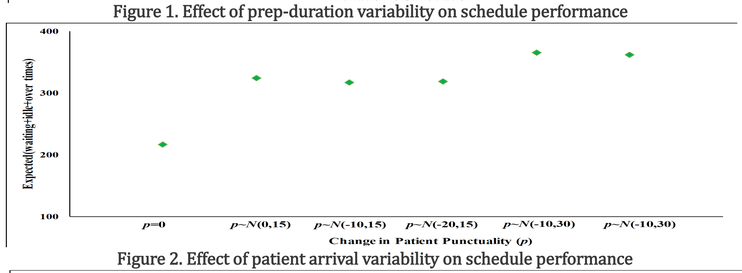


Figure 2. Effect of patient arrival variability on schedule performance

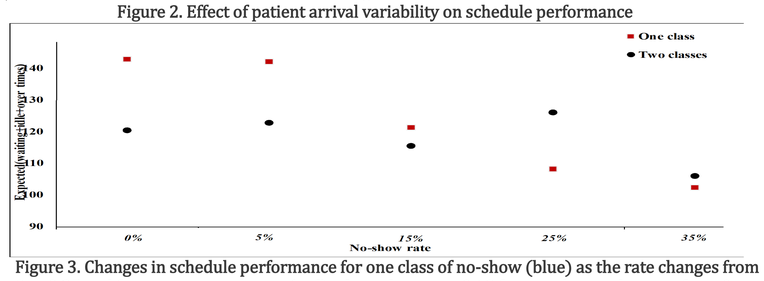


Figure 3. Changes in schedule performance for one class of no-show (blue) as the rate changes from 0 to 0.35 and for two patient classes (red) where the rate is 0.18 for one class and ranges from 0 to 0.35 for the other class

Future Directions

- Continue observation at the University of Michigan Medical Procedure Unit
- Include patient appointment time preferences
- Obtain a statistical approximation to patient procedure duration, no-show probability, and punctuality
- Design colonoscopy scheduling tool and use historical data to validate it and identify areas for improvement before implementing in practice

Acknowledgements

- The Seth Bonder Foundation
- The University of Michigan Gastroenterology Learning Community
- CHEPS students