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

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INFORMS, Nashville
November 14, 2016

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HEALTHCARE ENGINEERING & PATIENT SAFETY
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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

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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[1]

[1. Peery, Anne F., et al, 2012]

Colonoscopy Procedure

- Screening test for Colorectal Cancer (CRC)
  - 2nd leading cause of cancer-related death in the US[2]
- Enables a gastroenterologist to evaluate the inside of the large intestine (rectum and colon)
  - Identify existing cancer, prompting treatment
  - Prevent future cancer (***polyps***)

[2. American Cancer Society]

Colonoscopy Scheduling

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

Duration	Prep Quality	Health Conditions	No. of Polyps
Short (30 min)	Adequate	Good	Low
Long (90 min)	Poor	Poor	High

* 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

Duration	Prep Quality	Health Conditions	No. of Polyps
Short (30 min)	Adequate	Good	Low
Long (90 min)	Poor	Poor	High

≫ 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

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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

MCS: Pseudo Code

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```
Input  : Set of polices
Output: Performance metrics
for each policy do
    for  d=1:days do
        Assign patient a procedure duration type
        Policy dictates order and duration
        Process the patients throughout the day (actual schedule)
        Calculate the metrics for the day
    end
    Calculate the average of metrics over all simulation days for this policy
end
return Averages of metrics values over all days for each policy
Compare across policies
```

Figure 1: Monte Carlo simulation logic

MCS: Characteristics

- Single provider
- Provider and room are immediately available
- 18%[1] no-shows rate
- N procedures

Number of long procedures: N^l

- P(90 min) = p
- Cannot wait more than 60 minutes with high probability

Number of short procedures: $N - N^l$

- P(30 min) = p
- Cannot wait more than 60 minutes with low probability

[1.Berg et al. 2014]

Scenario 1

N^l=0.2N, p=0.75, Waiting Time

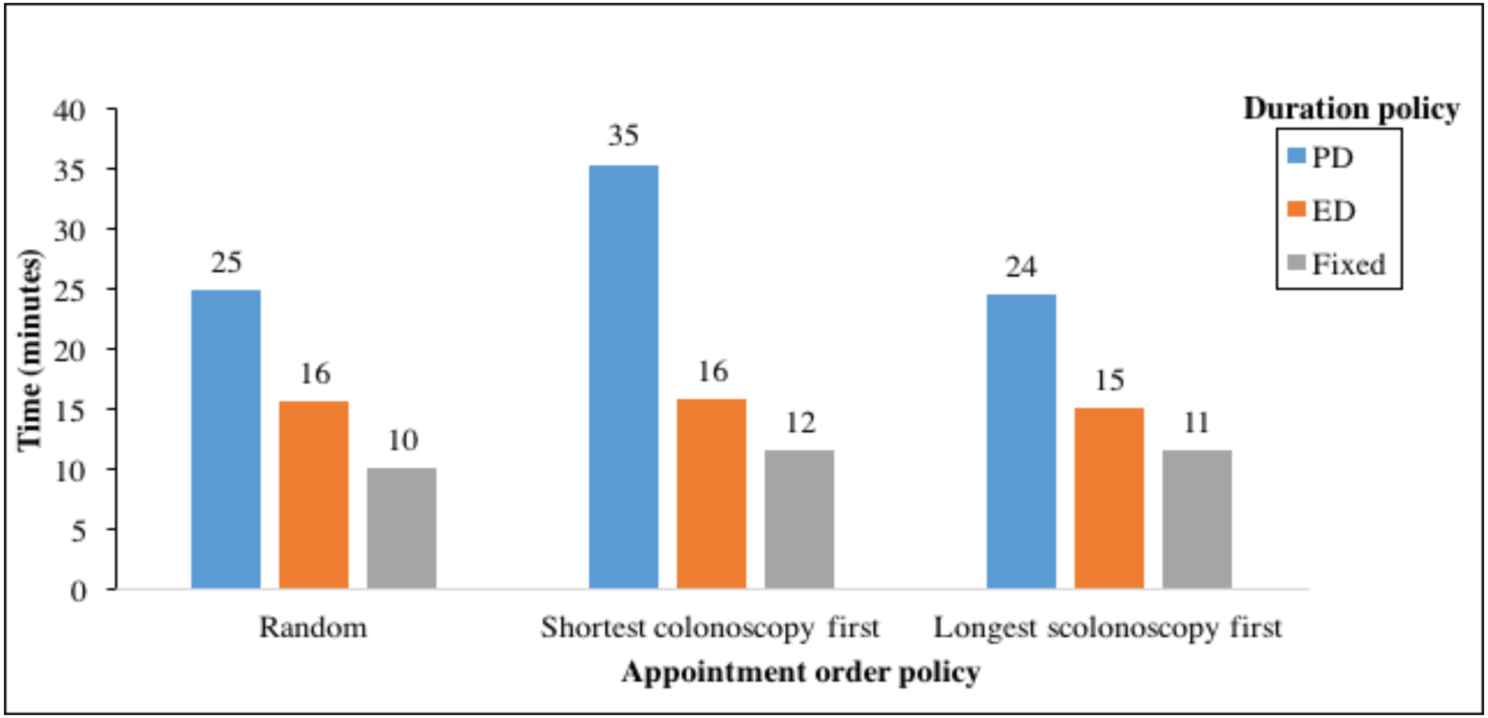

Figure 1: Average waiting time (patient/day)

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N^{l}=0.2N, p=0.75, No. of Cancelled procedures

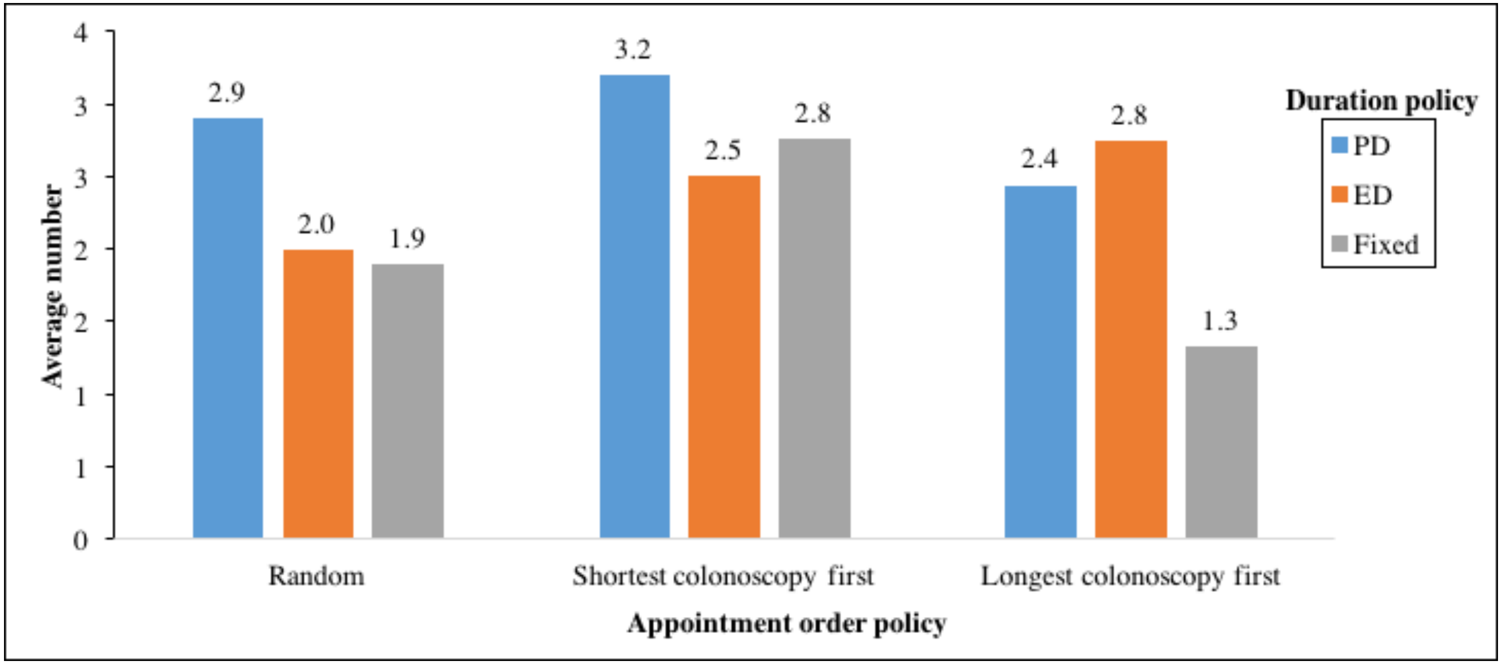

Figure 2: Average number of cancelled procedures (day)

Scenario 1

N^{l}=0.2N, p=0.75, Overtime

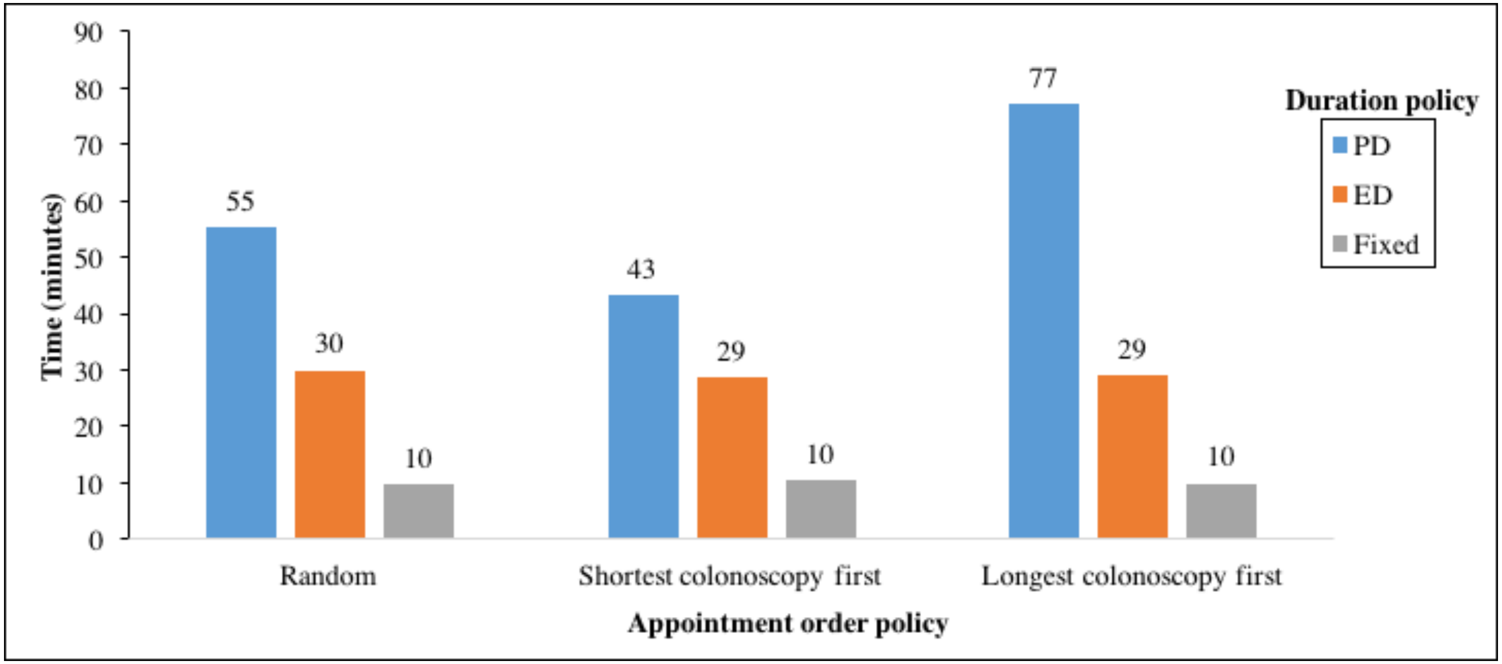

Figure 3: Average overtime (day)

Scenario 1

$N^{l}=0.2N$, $p=0.75$, Idle Time

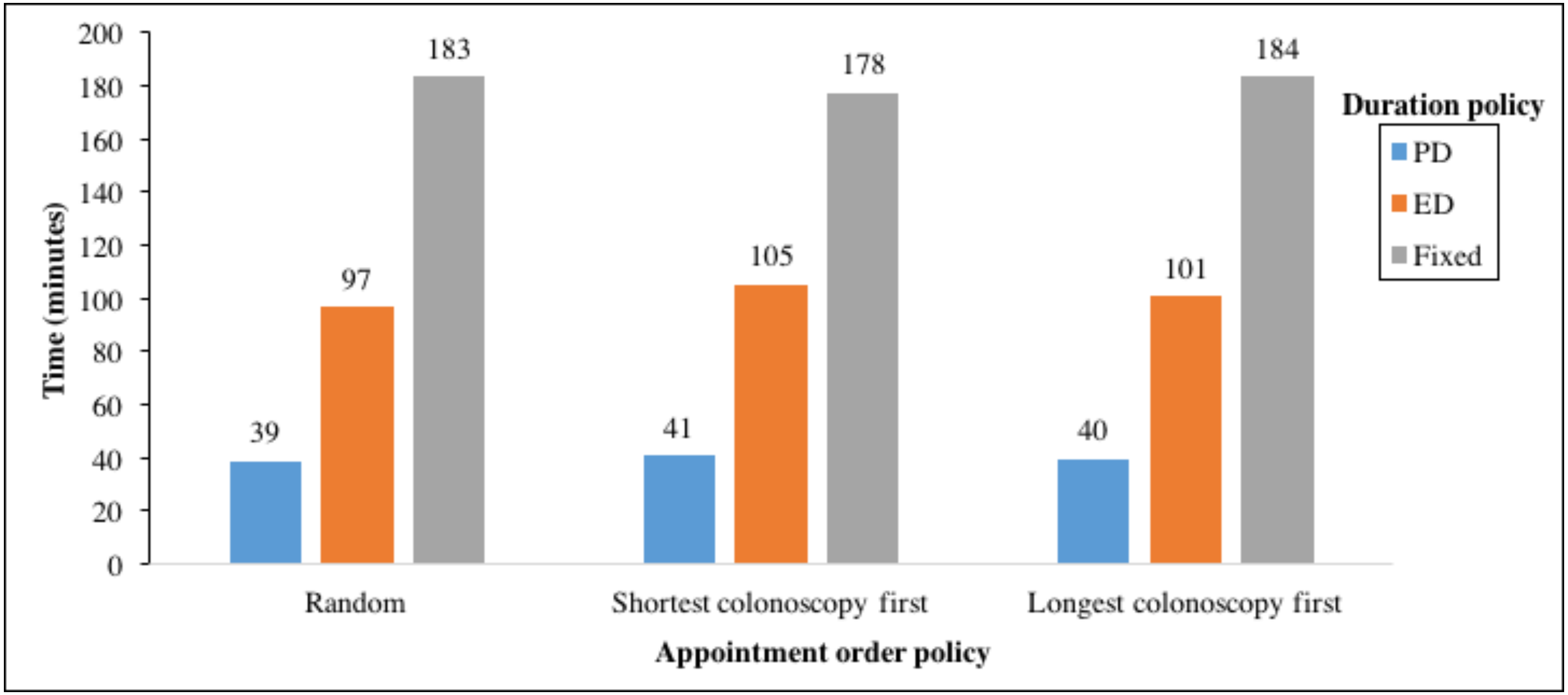

Figure 4: Average total idle time (day)

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Higher no-shows rate?

N^l=0.2N, p=0.75, rate=18%

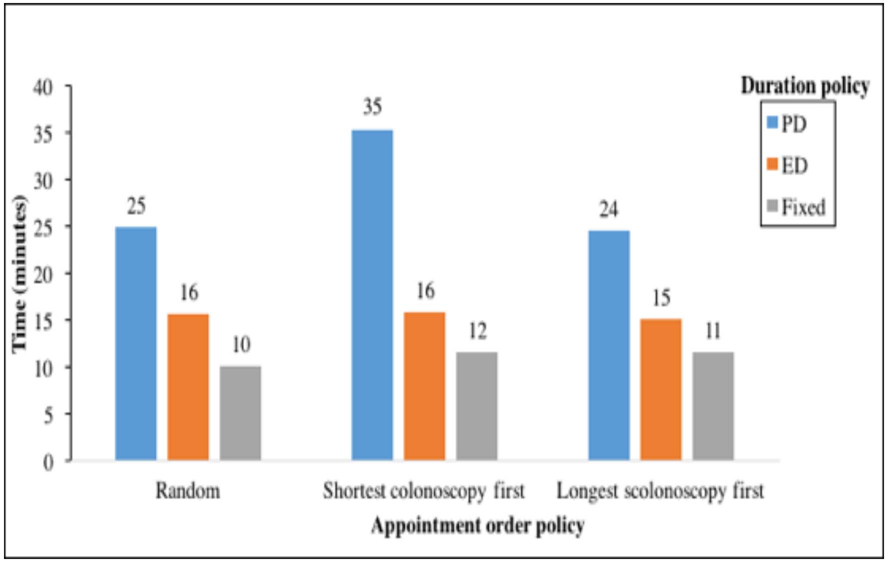

Figure 1: Average waiting time (patient/day)

N^l=0.2N, p=0.75, rate=35%

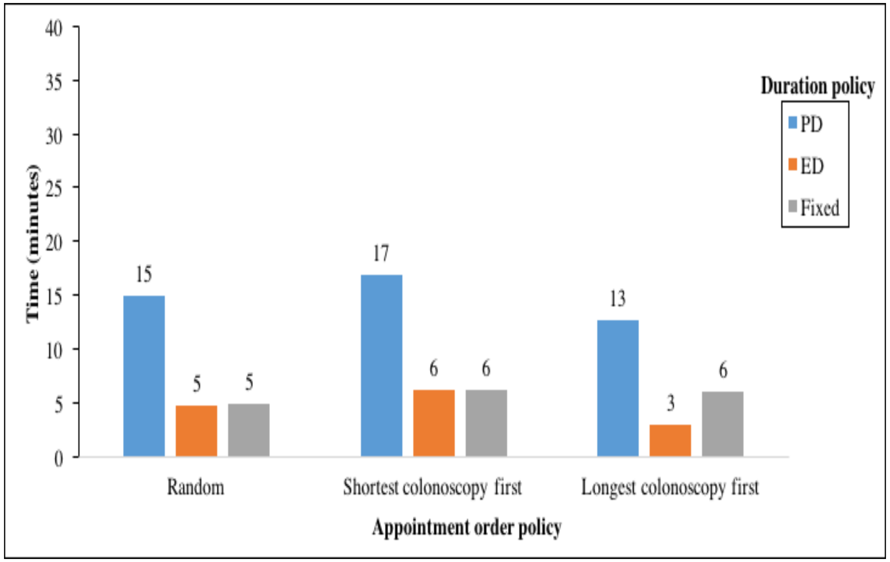

Figure 5: Average waiting time (patient/day)

* same performance, lower values

Higher no-shows rate?

N′=0.2N, p=0.75, rate=18%

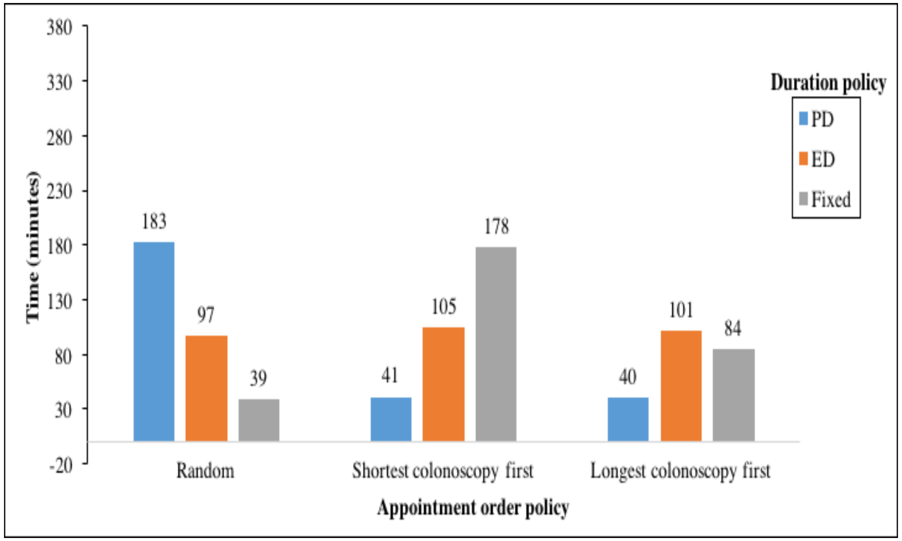

Figure 4: Average total idle time (day)

N′=0.2N, p=0.75, rate=35%

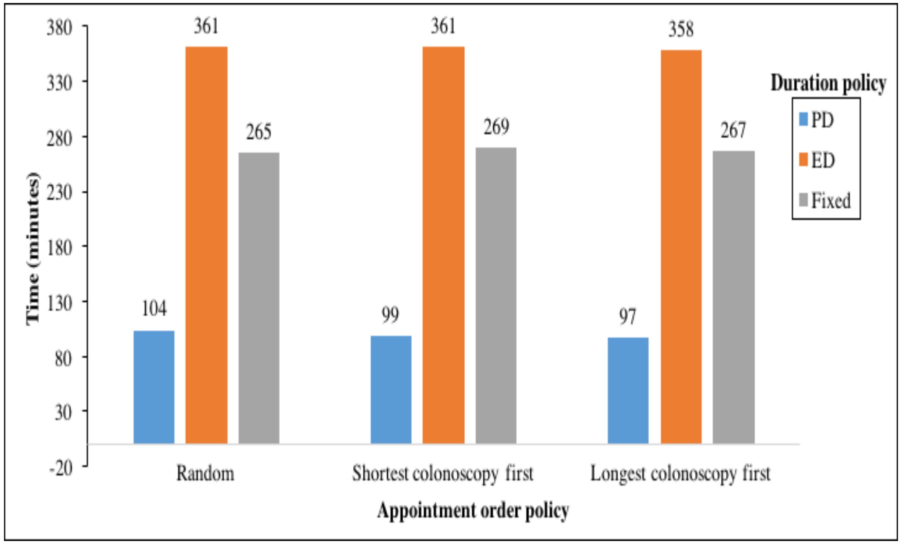

Figure 6: Average total idle time (day)

* higher values, more variability

Scenario 3

Lower *p*?

$N^{l}=0.2N$, $p=0.75$

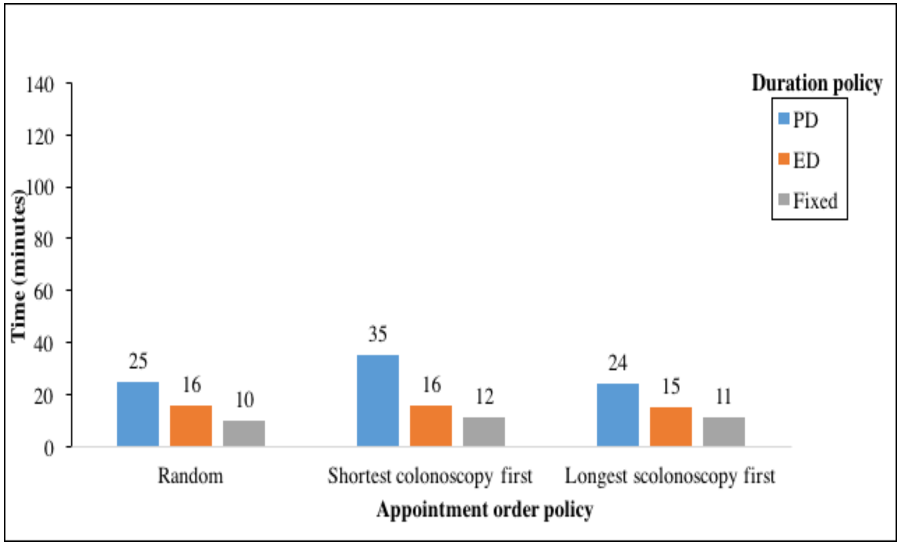

Figure 1: Average waiting time (patient/day)

$N^{l}=0.2N$, $p=0.25$

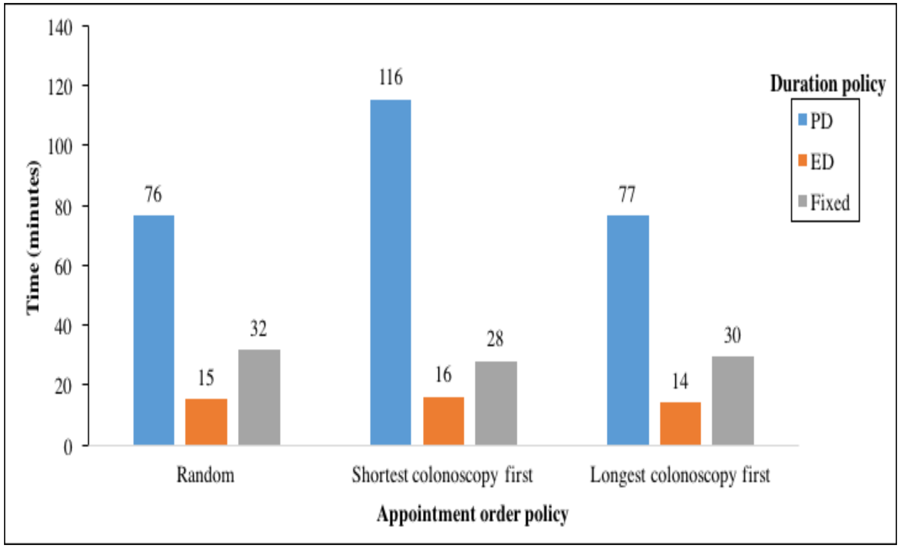

Figure 7: Average waiting time (patient/day)

*performance change, more variability

Scenario 4

Different population?

$N^{l}=0.2N$, $p=0.75$

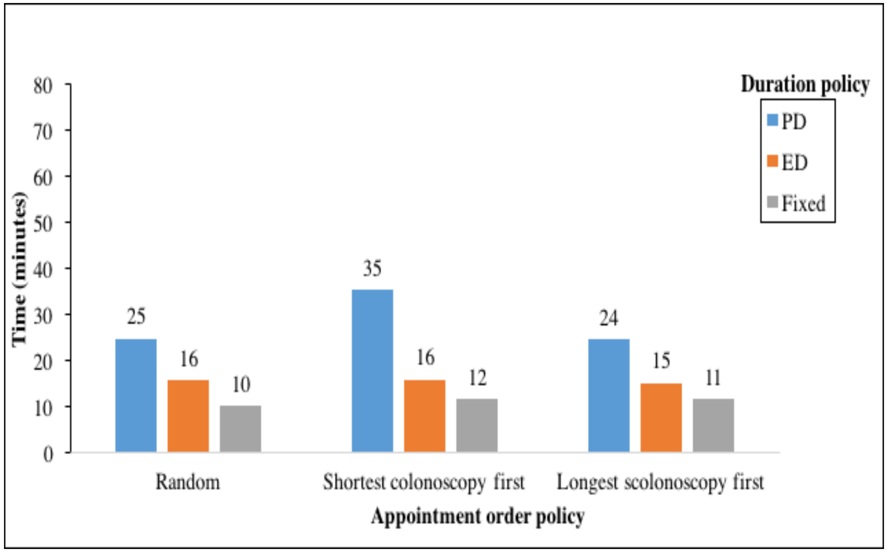

Figure 1: Average waiting time (patient/day)

$N^{l}=0.8N$, $p=0.75$

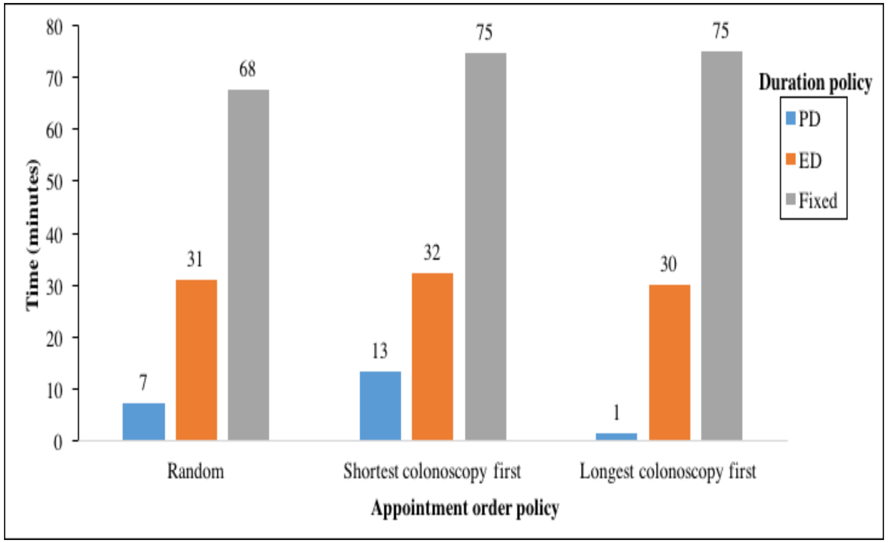

Figure 8: Average waiting time (patient/day)

*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
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- Key Messages
- **Future Directions**

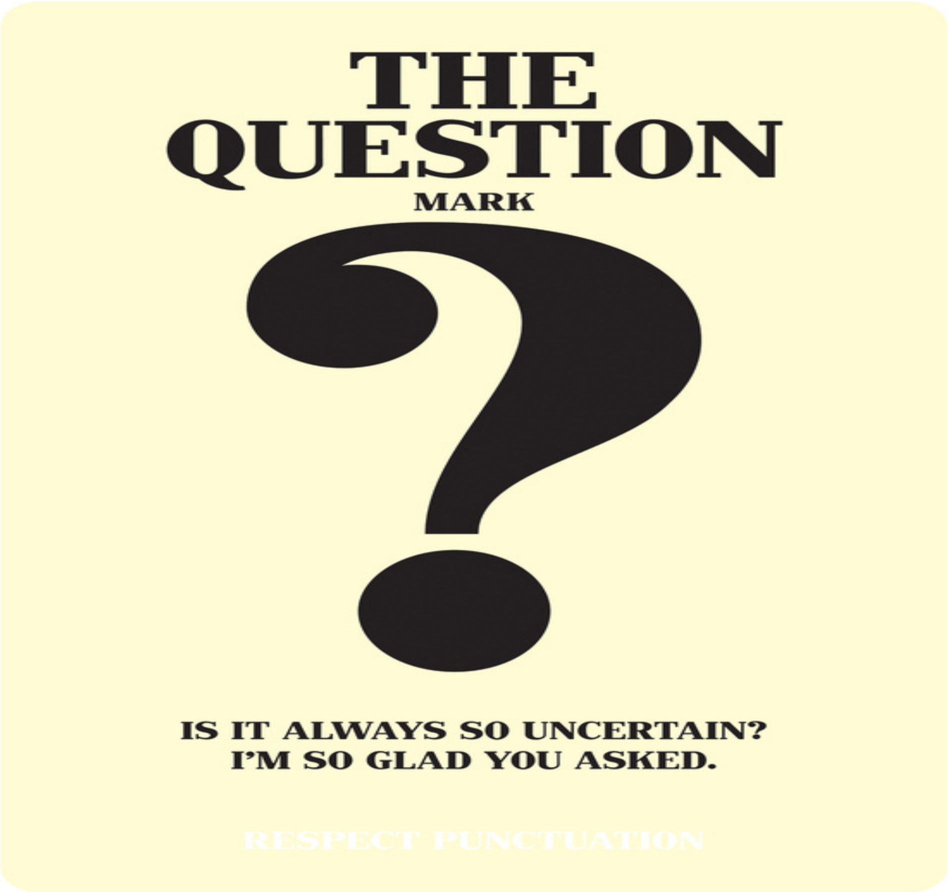
Future directions

- 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
- The Seth Bonder Foundation
- Summer Undergraduate Research in Engineering–SURE (for UM undergraduate students)
- We also express our gratitude to Dr. Jacob Kurlander, Dr. Sameer Saini and all CHEPS students who have contributed to this project

Questions



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References

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4. Schonberg, Mara A., et al. "Colon cancer screening in US adults aged 65 and older according to life expectancy and age." *Journal of the American Geriatrics Society* 63.4 (2015): 750-756.
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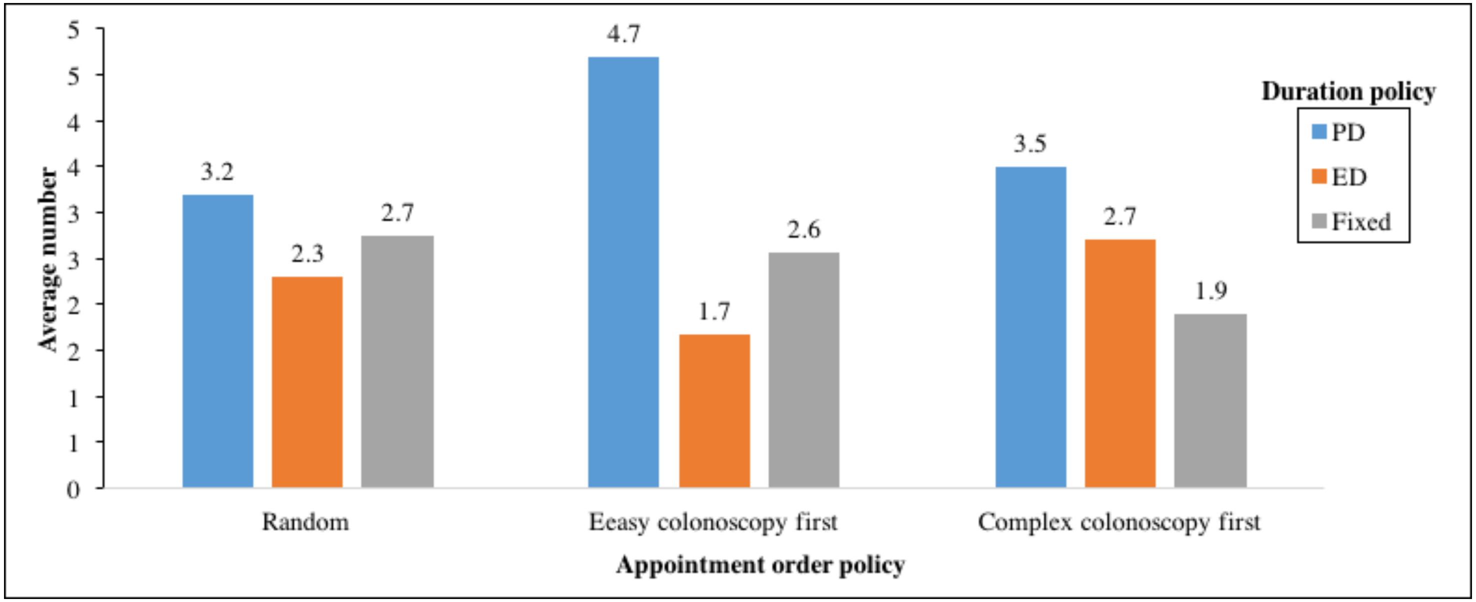
Scenario 2



5
5
4
4
3
3
2
2
1
1
0
Average number
3.2
2.3
2.7
4.7
1.7
2.6
3.5
2.7
1.9
Duration policy
PD
ED
Fixed
Random
Eeasy colonoscopy first
Complex colonoscopy first
Appointment order policy

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