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CENTER FOR HEALTHCARE ENGINEERING & PATIENT SAFETY
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Simulation of Patient Scheduling for Colonoscopy

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Problem Statement

Background

- Colorectal cancer (CRC) is the second leading cause of cancer-related deaths in the U.S.
- Colonoscopy can both identify existing cancers, so treatment can be started, and prevent future cancers, through the detection and removal of polyps.
- Largely due to the pre-procedure bowel prep, there can be significant variability in procedure time.
- This negatively impacts providers and capacity utilization. More importantly, long delays for patients can have negative health effects.

Patient Flow Overview

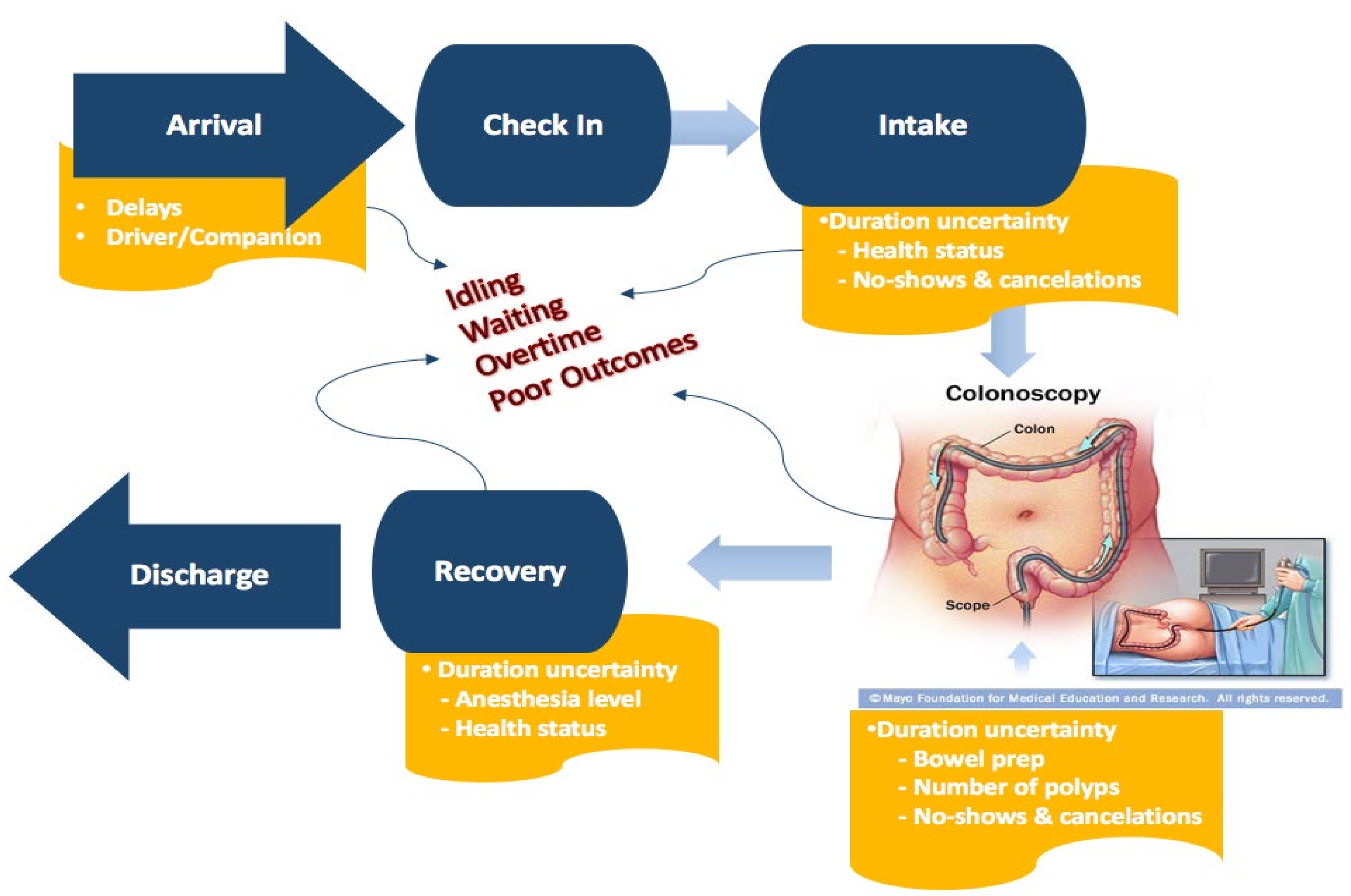

Figure 1: Typical flow of a single patient on the day of colonoscopy and major sources of variability highlighted

Objectives

- Develop a simulation-based framework for evaluating patient schedules under multiple criteria
- Analyze and compare several heuristic scheduling and sequencing rules

Methods

- Monte Carlo simulation to evaluate 8 different scheduling heuristics.
- Intake, procedure and recovery durations were generated uniformly using their minimum and maximum passible values based on expert knowledge and field observations.
- Evaluated results under 4 (potentially conflicting) metrics:
  1. Overtime.
  2. Idle time.
  3. Waiting time.
  4. Patient total time in the unit.

Table 1: Tested Heuristics

Heuristics	Ordering method
SPF:	Schedule procedures in ascending order of duration mean.
LPF:	Schedule procedures in descending order of duration mean.
SVF:	Schedule procedures in ascending order of duration variance.
LVF:	Schedule procedures in descending order of duration variance.
INP:	Schedule procedures in an ascending order of probability of no-show.
DNP:	Schedule procedures in an descending order of probability of no-show.
INPV:	Schedule procedures in an descending order of probability of no-show x duration variance.
DNPV:	Schedule procedures in an ascending order of probability of no-show x duration variance.

Basic Flow Logic

```
Input : Set of Heuristic
Output: Metric values
for each heuristic do
    for r=1:1000 do
        Randomly generate a "type" for each patient (which defines a distribution of treatment times).
        Generate a treatment time for that patient based on their corresponding distribution.
        Order the patients according to the policy.
        Process the patients throughout the day.
        Calculate the metrics for the day.
    end
    Calculate the average of metrics over all simulation days for this heuristic.
end
return Average of metric values over all days for each heuristic.
Compare across policies
```

Figure 2: Monte Carlo simulation logic for each heuristic

Preliminary Results

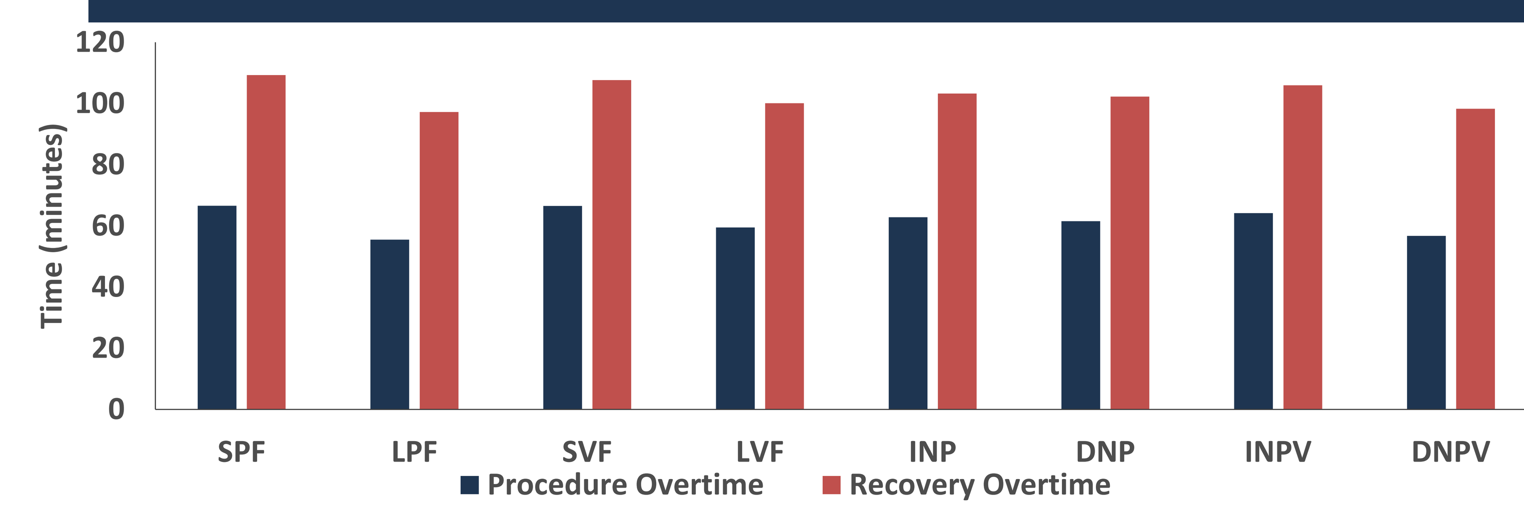

Figure 3: Average procedure and recovery rooms overtimes per day.

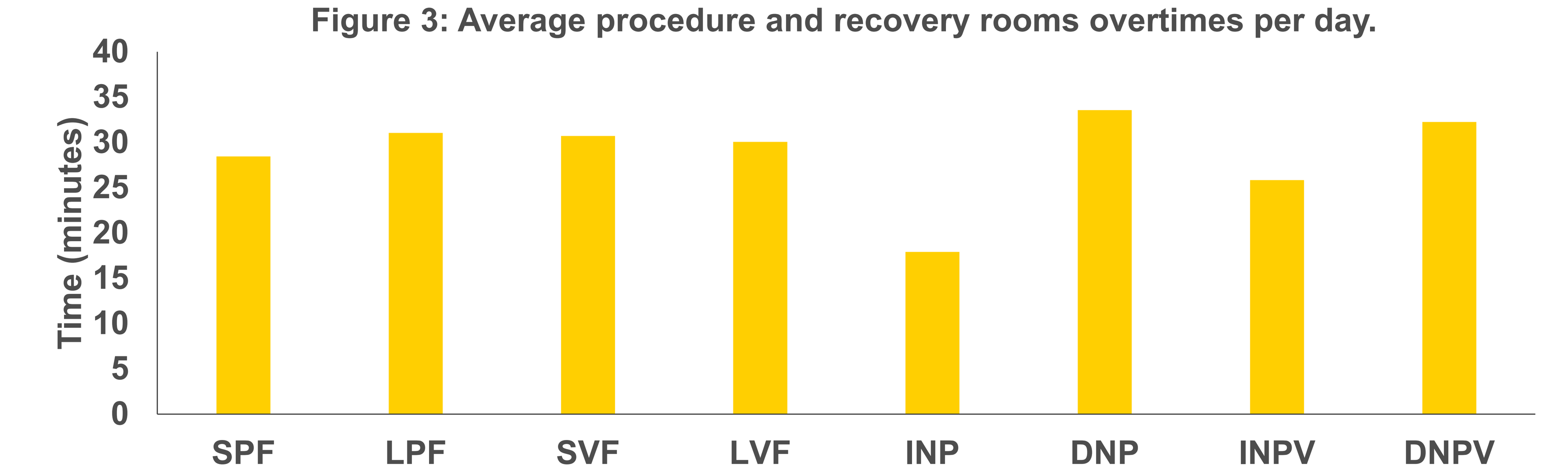

Figure 4: Average idle time per day

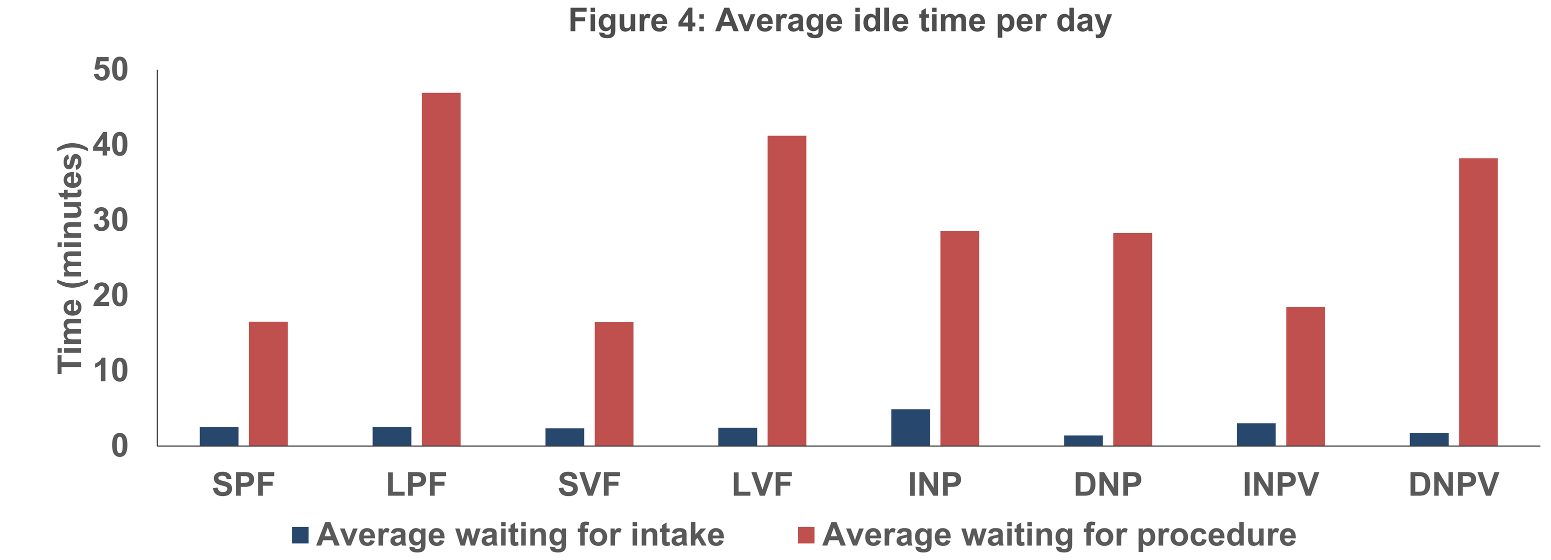

Figure 5: Average waiting time for intake and for procedure per day over all patients

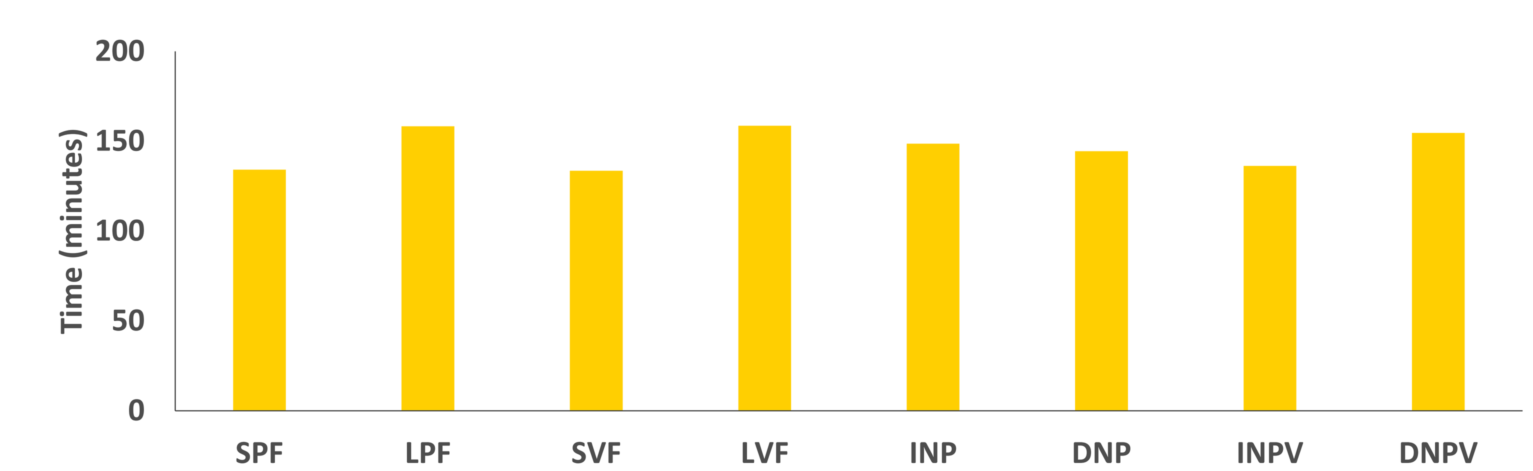

Figure 6: Average total time spent in the unit per day over all patients

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