*Proceedings of the 2020 Winter Simulation Conference*
*K.-H. Bae, B. Feng, S. Kim, S. Lazarova-Molnar, Z. Zheng, T. Roeder, and R. Thiesing, eds.*

# EVALUATING PATIENT TRIAGE STRATEGIES FOR NON-EMERGENCY OUTPATIENT PROCEDURES UNDER REDUCED CAPACITY DUE TO THE COVID-19 PANDEMIC

Adam VanDeusen
Che-Yi Liao
Advaidh Venkat
Amy Cohn

Industrial and Operations Engineering
University of Michigan
1205 Beal Ave.
Ann Arbor, MI 48109, USA

Jacob Kurlander
Sameer Saini

University of Michigan Medical School
1500 E. Medical Center Drive
Ann Arbor, MI 48109, USA

## 1 PROBLEM BACKGROUND

The COVID-19 pandemic has led to a remarkable number of hospitalizations and other demands on health systems, including the cancellation or deferral of non-emergency medical appointments (Hollander and Carr 2020). We can consider non-emergency appointments to be clinical visits that could be performed at a future date with little risk to a patient's condition worsening due to the delay. The length of time that non-emergency procedures can be delayed varies by the patient's condition and the severity of that condition.

During the pandemic, many appointments were canceled or deferred to reduce the number of people in clinical settings, thus minimizing infection risk. Additionally, during the pandemic, health systems shifted many clinical providers and resources to COVID-19 care. Finally, state-level government restrictions prohibited certain less urgent procedures (Joshi and Lewiss 2020). These factors led to reduced capacity for many appointments.

In this case study, we use colonoscopy as a demonstrative example of a non-emergency appointment. A colonoscopy is an outpatient gastroenterology procedure used to screen patients for colon cancer.

## 2 METHODS

We develop a discrete-event simulation to consider various scenarios for assigning patients to colonoscopy appointments under reduced capacity. We begin with capacity reduced to 5% of standard capacity, increased to 50% in 10 weeks, and to 100% capacity in 10 more weeks. The base unit of time in our model is weeks. We run the simulation for 150 weeks and replicate 100 times. Our simulation was coded in C++.

Patients arrive each week and are assigned a risk category from 1 to 4, with 1 being the most urgent patients and 4 being the least urgent. We consider four scenarios: (A) no triage strategies, (B) Category 4 patients are given an at-home test instead of colonoscopy and return as Category 1 patients in 4 weeks if at-home test is positive, (C) Scenario B plus Category 3 patients are deferred for 2 years, and (D) Scenario plus C plus half of Category 2 patient weekly arrivals are deferred for 6 months, half are assigned now.

In each week, we first assign patients with the highest urgency to colonoscopy, with those waiting longest being assigned first. Patients not assigned within a given week join a queue. Each risk category has a maximum waiting time (1 week for Category 1, 2 weeks for Category 2, 3 weeks for Category 3, and 5 weeks for Category 4), at which point patients exit the queue and seek care from another provider.

We consider 80 patient arrivals each week (Poisson-distributed), with 30% being Category 1, 20% Category 2, 30% Category 3 and 20% Category 4. At 100% capacity, there are 80 appointment slots. We report metrics such as wait time and number of patients reaching maximum waiting time.

## 3 RESULTS

As shown in Figure 1, as more triage strategies are implemented, we see a reduction in the number of patients who reach their maximum waiting time. Under Scenario B, this number is reduced among Category 4 patients and overall. Under Scenario C, which defers Category 3 patients for 2 years, this number continues to decrease, primarily due to Category 3 patients not being assigned for colonoscopy for approximately two-thirds of the simulated time. Moving from Scenario C to Scenario D, in which some Category 2 patients are deferred, has the smallest reduction in number of patients who reach maximum waiting time. When considering impact on average waiting time (Figure 2), we see reductions in average waiting time, especially for Category 4 patients, in scenarios beyond Scenario A. Note that this figure indicates average waiting time among patients *assigned* a colonoscopy (not including those who exit). Implementing more triage strategies both allows more patients to be seen and reduces average waiting time.

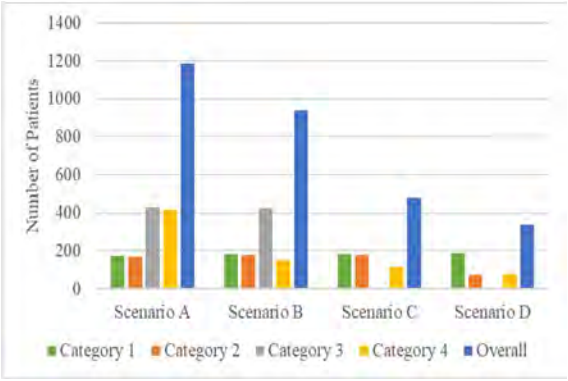


Figure 1: Number of patients who reach maximum waiting time under four scenarios.

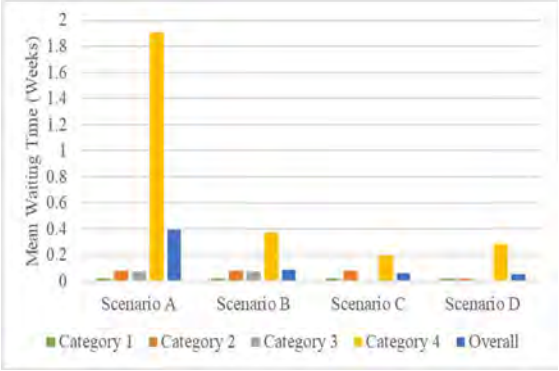


Figure 2: Average waiting time by patient category under four scenarios.

## 4 IMPACT AND BENEFITS

This simulation model can help clinical decision-makers understand how a pandemic-influenced reduced capacity for non-emergency procedures impacts patient wait time and other important metrics. Further, decision-makers can adjust their reopening plans and select triage strategies that help achieve meaningful outcomes for patients, while ensuring patient safety. The simulation model described here is modular to meet the needs of other clinical applications, and can be used for many analyses outside of this case study.

## REFERENCES

Hollander, J. E., and B. G. Carr. 2020. "Virtually Perfect? Telemedicine for Covid-19". *New England Journal of Medicine* 382:1679-1681.

Joshi, A. U., and R.E. Lewiss. 2020. "Can Telehealth Save the American Healthcare System from an In- Person Patient Care Collapse?" *European Journal of Emergency Medicine* 27(4):249-250.