INTRODUCTION

Key Goal: Reduce patient waiting time by mixing chemotherapy drugs before patients arrive in the system or at earlier stages in the process.

Motivation:
- Second leading cause of death in the U.S.
- 1.7 million estimated cases in 2017
- More than half require chemotherapy treatment
- Inflation issues
- Increased outpatient demand leads to undertakable outcomes such as
  - Increased patient waiting times
  - Overworked staff

Lastly, we note that there were over 200 treatment protocols. However, in order to fit a model we needed to reduce the number of categories based on frequency.

Dissertation Summary

- University of Michigan Comprehensive Cancer Center Data from 2015
- 3,522 total patients in sample

Table 1 (a) contains all tested numeric variables while Table 1 (b) represents all categorical variables. We see that there were over 100 treatment protocols. Therefore, in order to avoid overfitting we need to reduce the number of categories based on frequency.

Table 2. Model results

What is Pre-mix?

- Anytime the pharmacy mixes a drug before a patient is deemed ready to receive it
- Generally pharmacies do not pre-mix drugs due to risk in wastage cost
- Consider the trade off between wastage cost and reduced patient waiting time

UNMC Pre-Mix Policy
- Will only pre-mix drugs from 8am-7:30pm (before patient arrive)
- Will only pre-mix drugs from a fixed list (based on cost and pharmacist-described "common use")

We expand this by considering patient probability of deferral and the number of patients scheduled for a particular drug.

1. PREDICTION

Suppose we have five patients scheduled to receive 100 mg of Taxotere on a given day. If the first patient defers/does not arrive we can then give their drug to the second and so on. Therefore to waste one dose, all patients must defer or not show up.

Probability of wasting the second dose pre-mixed: 100 mg Taxotere

2. OPTIMIZATION

We consider having a fixed window for pre-mix (2 hours) and want to determine which drugs to mix in order to maximize expected saved wait time and minimize expected waste costs. The expectation is determined from the probabilities discussed in Chapter 1.

Assumptions:
- All drugs will wait for all patients scheduled that day (most last 12 hours)
- All drugs’ mixing times are deterministic
- Each patient is scheduled for only one drug

Model

Objective: Maximize the difference between our expected saved wait time and waste cost

\[
\text{Waste Cost} = \sum_{j=1}^{n} \text{Cost of Drug } j
\]

\[
\text{Expected Saved Wait} = \sum_{j=1}^{n} \text{Expected Saved Wait for Drug } j
\]

Constraints:
- Either pick a time to start a drug or do not make it at all
- Drug must be completed if mixed
- If you do not make the 4th dose you cannot make the n=4 dose
- Must make doses in order
- Can only make C drugs at a time
- No preemptions allowed
- Cannot start a drug unless there is enough time
- Drug must go through stage 1 before stage 2

Evaluation of the optimization model using the simulation and compare with the "rule of thumb" policies

3. SIMULATION

UNMC has a goal to keep the drug order turnaround-time (TAT) under 1 hour for each patient. However, current TAT can be as much as 2 hours. Our focus is to improve the drug order TAT in the pharmacy and in turn reduce the overall turnaround-time system for patients.

We propose various pre-mix policies ranging in risk tolerance to be tested through discrete-event simulation while considering the trade-off of saved wait time vs. cost. We fit a parameter to the patient deferral.

We assume that all pre-mixed orders will not expire before they are administered if the patient appointment is at noon or before.

We assume a single arrival stream of patients.

We assume a single drug order for each patient with a drug probability of deferral of 5%.

There is also a chance for pre-mixed orders to be wasted if a patient defers or does not show.

Simulation was done using the Styx module in Python. The results below were obtained through 20 replications of a Monday-Friday at UNMC.

Results

- Drug Order Time in Minutes and Weighted Root Errors

Table 3. We know the results for the drug order time in minutes. System 1 presents the first 20 drugs for patients with a probability of deferral of one of the deferral scenario. System 2 through 4, the probability of deferral is derived from the University of Michigan Cancer Center patient deferral data. The deferral probability is based on each block based on the number of appointments in that block. System 3 combines both ideas from system 2 and 4.

Future Work

- Use the expected saved wait time by following recommendations taken from the static pre-mix model solution from Chapter 2
- Test various policies for mixing chemotherapy drugs throughout the day

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