Computer simulation and mathematical optimization to reduce patient wait times in an outpatient infusion center

A. Heiney, M.S., R.N.; S. Potiris, B.S.; J. Castaing, B.S.; A. Cohn, Ph.D.; B.T. Denton, Ph.D.; C.R. Friese, Ph.D.

CHEPS Center for Healthcare Engineering & Patient Safety
MICHIGAN ENGINEERING
http://sitemaker.umich.edu/cheps

University of Michigan Health System

For more information, please contact Professor Amy Cohn, Associate Director of the Center for Healthcare Engineering and Patient Safety. E-mail: CHEPSadmin@umich.edu

ABSTRACT

As cancer treatment demand outpaces the capacity of ambulatory infusion centers, clinicians are challenged to provide timely, cost-effective, safe, and patient-centered care. Reduction in patient wait times can help address these challenges through more efficient care delivery. To reduce patient waiting times and operating hours, we developed a mathematical optimization model and easy to implement heuristics to generate patient appointment times at an infusion center. Our models explicitly considered the uncertainty of patient infusion times. We also created a detailed discrete event simulation model to evaluate the performance of the new patient appointment schedules. We observe that scheduling patients with longer infusion times earlier in the day results in shorter patient waiting times and total length of day of operations.

METHODS

- 60+ hours of student observations
- 37,000 records of patient visits were reviewed from 3 different electronic health records
- Integration of patient visit data

Observations & Data

Patient Flow Mapping

- Patient and process flow were mapped after observations in the reception area, infusion area, oncology clinics, and pharmacy and
- Validated through expert opinion

Heuristics | **Simulation Model** | **Optimization Model**

Output

Analysis

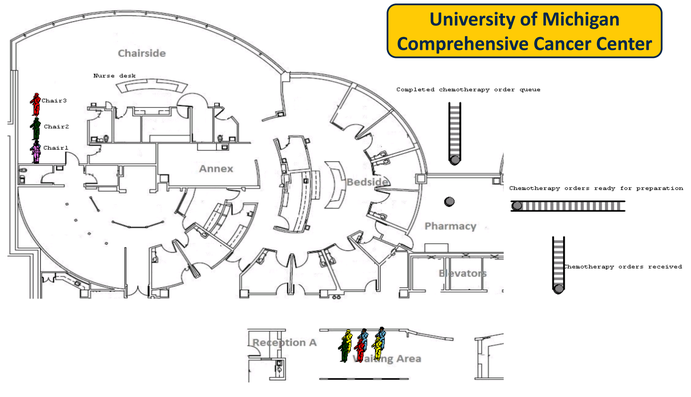
Scheduling Heuristics
- LPT: Patients with longer infusion times are scheduled earlier in the day
- SPT: Patients with shorter infusion times are scheduled earlier in the day

- Computer simulation allows us to evaluate the effect of different appointment schedules in the infusion area without disrupting its operations

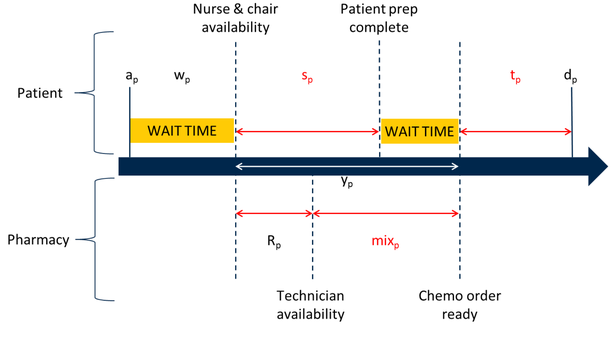
COMPUTER SIMULATION

Computer simulation is used to recreate a simple version of the operation of an infusion pod on a regular weekday at the University of Michigan Health System outpatient infusion center

- Features
  - 12 patients
  - 1 RN
  - 1 pharmacy technician
- Operations duration: 14 hours
- Input
  - Patient types
  - Nurse preparation time
  - Nurse discharge time
  - Pharmacy preparation time
- Appointment schedules
  - Baseline
  - Longest Processing Time (LPT)
  - Shortest Processing Time (SPT)
  - Optimization model
- Output:
  - Average patient waiting times
  - Hours of operation
  - Chair utilization
  - Average time in infusion center

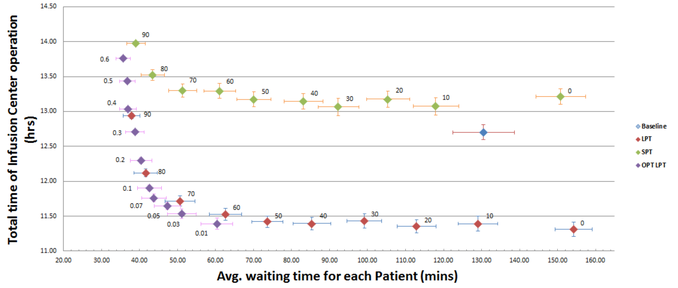


OPTIMIZATION MODEL



- Goal: Generate appointment schedules that reduce patient waiting times and total length of day of operations
- Results: Appointment times, Patient sequence, Patient-chair assignment
- Type of model: Stochastic
  - The use of a stochastic model allows us to account for the uncertainty associated with the duration of patients' infusion and the effect on the length of day and wait times
  - Each scenario in the model assigns a particular infusion time to each patient
  - The variability in each patient's infusion time is accounted for by solving the model for multiple scenarios

RESULTS



- Appointment schedules generated by the optimization model result in reduced patient wait times and total hours of operation compared to the ones generated by the Baseline schedule, and the LPT and SPT heuristics
- Initial results demonstrate a 70% reduction in patient wait times using the appointment schedules generated by the optimization model

CONCLUSIONS

- The effect of implementing different patient appointment schedules at an infusion center can be approximated by a mathematical optimization model
- Results of computer simulation suggest that scheduling patients with longer infusion times earlier in the day results in reduced patient wait times and total length of day

FUTURE RESEARCH

- Faster to solve optimization model generating better appointment schedules
- Development of a heuristic that can be easily implemented by schedulers
- Enhancing simulation model
  - Addition of oncology clinic, increased complexity with additional nurses, chairs and patients

ACKNOWLEDGEMENTS

This research is generously supported by:
- Center for Healthcare Engineering and Patient Safety, The Seth Bonder Foundation, The Doctors Company Foundation, UM College of Engineering SURE Program, UMHS Comprehensive Cancer Center