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AN APPLICATION OF DISCRETE EVENT SIMULATION FOR PLANNING AND RESOURCE ALLOCATION IN A STATE HOSPITAL SYSTEM SERVICING BOTH CRIMINAL AND CIVIL COMMITMENTS

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ABSTRACT

A discrete event simulation (DES) model with Auto-Regressive Integrated Moving Average (ARIMA) forecast inputs, sampled service times, resource capacities and scheduled resource changes was used to project inpatient populations, referral waitlists, and bed utilization for a five-site hospital system with over 10,000 patients. Based on a SAS Simulation Studio platform, the model can project arbitrary subpopulations on a three-year horizon and perform "what if" experiments with bed allocations and patient flows. This application demonstrates the utility of DES for providers with statutory obligations to serve forensic populations, while also exposing the limitations presented by missing data, non-random variations in data collection across sites, and sizable exogenous variation.

1 INTRODUCTION

California's Department of State Hospitals (DSH) evaluates and treats six forensic populations: Incompetent to Stand Trial's (ISTs), Not Guilty by Reason of Insanity's (NGRIs), Mentally Disordered Offenders (MDOs), Sexually Violent Predators (SVPs) and civil commitments/conservatorships under the Lanterman-Petris-Short Act (LPSs). The DSH operates five treatment facilities across the state. Within the facilities, beds are licensed to service specific subpopulations. In addition, high acuity and/or violent patients must be housed in secure facilities. In order to efficiently house and service its complex population while complying with statutory deadlines, the DSH must match patient needs to appropriate beds and resources. The Irvine Simulation Modeling Lab (ISML) developed a discrete event simulation (DES) model based on the SAS Simulation Studio platform. The model projects inpatient populations, referral waiting times, and bed utilization on a three year horizon.

2 QUEUEING MODEL STRUCTURE

ISML's DES model operates as a queueing structure with entity (patient) movements determined by appropriate resource availability. A concept map of the population centers and patient flows is displayed in Figure 1.

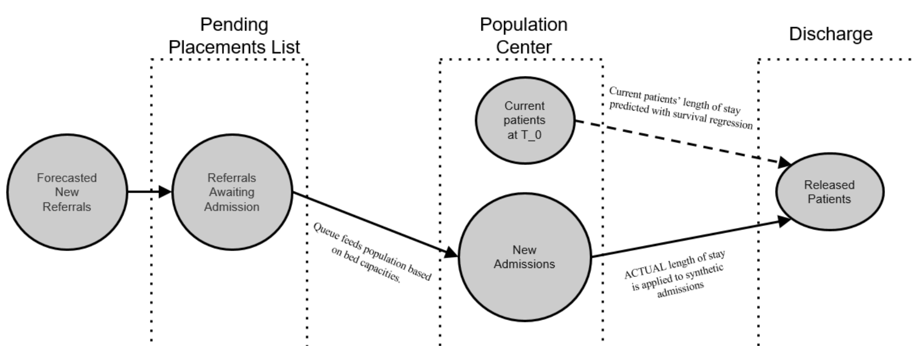

Figure 1. Concept map of DES model population centers and patient flows

Beds in each unit are represented as resource entities available only to patients for which the unit is licensed to service. The pool of available beds are grouped by site and unit. Patients enter the model as forecasted and sampled new referrals. As patients move through the model, they carry with them a trailing banner of demographic information, classifying attributes, and time stamps. Referred patients wait in queues for a bed to open up in an appropriate admission unit. When a bed becomes available, patients are pulled into an admission unit where they wait for a housing unit bed. Once patients reach a housing unit, they are held there until their sampled service time has elapsed. They are then discharged, opening the bed for a patient held in an admission unit. Patient entities have time stamps added to their banner of trailing information when they are generated as a new referral, enter an admission unit, enter a housing unit, and finally at their discharge time.

3 MODEL INPUTS

The DES model is driven by three demand-side model inputs, (1) Auto-Regressive Integrated Moving Average (ARIMA) forecasted new referrals by patient type, (2) historical patients with uncensored service times sampled to represent the forecasted referrals, and (3) service times for censored current patients sampled from uncensored patients similar in demographic profile. These three inputs determine the rate of new referrals, the demographics and service times of new referrals, and remaining time until discharge. The supply-side inputs consist of bed capacities of each hospital unit as well as the priority routing structure designed to route patients to the most appropriate bed available to them while also allowing units that service multiple patient types to change in patient composition as demand changes over simulated time.

4 SUBPOPULATION PROJECTIONS

The primary function of the DES model is to produce arbitrary subpopulation projections from the results of a single simulation run. Whereas systems dynamics models and other "top-down" models must define their subpopulations prior to initiating a simulation run, the DES model can produce subpopulation projections for any group which can be defined by the demographics and attributes entities carry and time stamp throughout the model. Since entity genders, patient types, county of origin, and other interesting identifiers are carried by entities throughout the model, the waitlist and inpatient population for any simulated week can be produced by counting the entities with a given attribute and appropriate referral, admission, housing, and discharge time stamps. If handedness were available for all patients, the DES model would be capable of estimating the number of left-handed inpatients without executing a new simulation run designed specifically for that subpopulation.

5 "WHAT IF" EXPERIMENTS

While estimating arbitrary subpopulations is a very convenient feature of the DES model, performing "what if" experiments with bed capacities and patient routing is an arguably more powerful function. Once a baseline simulation result is produced to mimic the *status quo* DSH system, proposed changes to bed capacities and unit structure can be evaluated by comparing the baseline result to the results of the model representing the proposed changes. These experiments are particularly useful for planning purposes, as they can answer questions such as: "How many beds would we need to make available for patient type X over the next three years in order to keep referrals waiting times under three months?"

6 CONCLUSION

The utility of our DES model for resource allocation and other planning purposes is obvious. DSH is now able to simulate the impact of projects such as construction, renovation, unit closure, and bed reclassification on the length of the referrals waitlist. With our DES model at their disposal, DSH can adjust the timing and scope of these projects, as well as add transition resources to keep waitlists under a maximum length. Future iterations of this model will introduce new resource classifications such as psychiatrists, security, social workers, and nurses to address questions regarding staffing efficiency and utilization.

REFERENCES

Bartos, Bradley and McCleary, Richard. (2015). Generic Discrete-Event Simulation Model of a Prison (June 24, 2015). Available at SSRN: http://ssrn.com/abstract=2622783