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CAPACITY MANAGEMENT AND PATIENT SCHEDULING IN AN OUTPATIENT CLINIC USING DISCRETE EVENT SIMULATION

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ABSTRACT

An outpatient clinic faces frequent appointment requests and visits from different classes of patients each day. Although the patients arriving to the outpatient clinic may not be in a critical condition, it is still very important for the clinic to have adequate appointments to serve patients without significant delay in order to not lose patients and provide patient access. Considering the various uncertainties in the demand structure and appointment calendars in outpatient clinics, this task is very challenging and requires a lot of time and effort. Furthermore, due to high demand and limited capacity in these clinics, it is crucial to manage capacity effectively and efficiently. These clinics seek to avoid schedules to result in physician idle time or delay in patient appointment dates due to improper capacity management.

Capacity management in an outpatient clinic can be analyzed considering two elements: demand and the schedules of the resources. Demand is usually generated by multiple patient groups. In the large outpatient clinic that motivates our research, there are four patient categories: new external patients, internal patients, established patients, and subsequent visit patients. New external patients are new to the clinic and usually have longer appointments. Internal patients are referred to this department from another department within the clinic but they are new to this department. These patients can have shorter appointments compared to the external patients. Established patients are the patients that have been seen previously and can have short, medium or long appointments. Subsequent visit patients are the patients who return for follow-up control, and usually require shorter appointments. Another important aspect that is related to the demand structure is the patient behavior. Patients have different tendencies to cancel or reschedule their appointments, or show-up for their appointments. It was pointed out by a previous paper that cancellation and no-show rates increase with appointment delay, i.e., the time between the appointment request date and the actual appointment date. In addition to these behaviors, we also observe that the reschedule rates are also affected by the delay. Thus in this study the behaviors are predicated on the appointment delay. To the best of our knowledge, none of the papers in the related literature takes delay-based cancellations, reschedules and no-shows in to account. Another complicating factor in this problem is that different classes of patients have different revenue potential. For this reason it is important to take monetary value into account and evaluate the trade-off between scheduling a patient of a certain type to an earlier versus a later date considering the behavior and the revenue of different patient classes.

Traditional scheduling systems consist of unique calendars devoted to each physician and in general physicians manage their own calendar in terms of when to have internal patient visits or external patient visits or time that they reserve for research, etc. Thus each calendar is uniquely designed and filled for a physician. These personal calendars have predefined slots for each patient category. Appointments are assigned to these slots based on the appointment type – slot designation matching. If the slots of a certain type are full and a patient requests an appointment, then that patient will be scheduled for an appointment

further into the future. Moreover, according to our data analysis we observe that the further the appointment is, the more likely that it will be cancelled or rescheduled. This results in unfilled or overbooked slots.

For this study, two years of data has been used to characterize the current state of the clinic, to find both the patient related attributes (demand and behavioral functions) and capacity related parameters (daily available capacities for each subspecialty). After obtaining the necessary parameters and functions we build a simulation model in Arena, validate the current system model with the actual data, and we experiment with different scenarios to see the effects of changes. We use a discrete event simulation rather than an analytical model, due to complicating factor of delay based behaviors, especially the rescheduling behavior because the papers in the existing literature end up having curse of dimensionality in their models and come up with heuristics even though they do not consider delay-based cancellations, reschedules and no-shows. The validation of our simulation model has been done based on the proportions of seen, cancelled and no-show patient appointments, as well as the days spent in the system by the patients that are seen without any change in their appointment dates number of days spent. In our study, instead of predefined slots we use generic slots of specified length whose number is set based on the current usable overall capacity for each subspecialty in the clinic. In other words, we use physician pools based on their subspecialties and assume that the patient is willing to see any of the physicians in that pool. This work is an extension of our previous work, in which we have shown the effects of reducing appointment windows for all patient types at the same time by the same amount, under the performance indicators of the seen patient percentages and utilizations. In that study we observed that reducing all appointment windows improves the system, however we did not measure the effect on the daily net revenue. In that paper we also ignored the fact that the subsequent visits were actually generated by other types of appointments, and we assumed that all appointment types were independent of each other. In this study we consider different appointment windows for different patient classes, different revenues obtained by seeing patients of different classes, and the subsequent visits are generated by the other three classes of patients.

We generate 54 scenarios to evaluate using the appointment choice set that is obtained with an expert opinion. Based on our results we conclude that it is possible to significantly improve all of our performance indicators by using the settings, in which the largest appointment window is 1 week for internal patients, 6 weeks for new external patients, 6 weeks for subsequent visit patients, and 12 weeks for established patients. In other words, by only making these changes in the current system we can improve the clinic performance indicators significantly. However, although all scenarios are better than the current system, if we compare the proposed scenarios by each other, we cannot directly conclude that reducing appointment windows always increases the performance indicators. For example, for the internal patients reducing the appointment windows to 1 day is actually worse than 2 days. We can explain this with the fact that filling the next day with the internal patients would cause other patients to not be able to enter the system in a timely manner, and given the lower revenue obtained from internal patients, it is not worthwhile to give them next day appointments. However, with the new external patients we observe an increase in the net profit in most cases as we reduce the appointment window, this is due to high revenue that they bring into the clinic and compensates for delaying patients of other types. For this reason, it is important for the clinic to prioritize their performance indicators while considering the trade-off between scheduling a patient of a certain class to an earlier versus a later day by taking their blocking effect on the system into account.