



Improving an outpatient clinic utilization using decision analysis-based patient scheduling



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ABSTRACT

This study presents a predictive model to be used in scheduling patients in an urban outpatient clinic. The model is based upon actual patient characteristics from a physical therapy clinic within an urban health and wellness center situated in a public university. A number of reported patients' characteristics such as age, education level, distance from the clinic, historical attendance records, etc. were examined to determine if they significantly impacted the patients' missing scheduled appointments (no-shows.) Decision tree analysis was used to develop a model that assessed the likelihood of a patient's no-show, using key patient characteristics and attendance records. Such a model can be used to assist with scheduling patients in an outpatient clinic, while attempting to increase the clinic's overall utilization. Four tree growing criteria were examined to develop the model with the strongest predictive power. Predictive power of each method was assessed by using the entire dataset as well as using split sampling. The results were then compared with those of a Bayesian networks model and a neural networks model. In addition, the trade-off between the selected decision tree model's predictive power versus simplicity of the associated classification rules was examined. We also assessed the impact of various levels of overbooking on the clinic's utilization when using patients' schedules based on the predictive model.

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1. Introduction

Excessive patients' failure to keep scheduled appointments in outpatient clinics is costly and disruptive, resulting in the scheduling process that requires great attention and a systematic approach. Patients' failure to keep a scheduled appointment (no-shows) in academic medical centers and urban settings, especially those with a relatively large population of socio-economically disadvantaged patients has been shown to be more recurrent [1–3]. Further, if the clinic offers opportunities for outpatient clinical research, no-shows can be quite disruptive to the research process with negative consequences including erroneous research findings [4].

Several factors affect patients' decision to miss scheduled appointments. In a comprehensive survey of the literature, Deyo and Inui [4] summarize factors that may affect no-shows. They grouped the reasons for no-shows into categories such as demographics,

sociobehavioral, environmental, access factors, provider's features, features of the facility, and the therapist's features.

Affirmation of quantitative factors relating to no-shows has been studied using various statistical techniques. Dove and Schneider [5] used a decision tree model to study 756 patients affiliated with Haven VA Medical Center. They used the patient's last appointment record (missed or kept) as the dependent variable. Their study revealed that age, appointment interval, travel distance and previous missed appointment record were significantly related to no-shows. More recently, Lee et al. [6] studied a sample of 22,864 patients receiving care from the Tan Tock Seng Hospital, Singapore from 2000 to 2004. Using multiple logistic regression analysis, they found that age, race, days from scheduled appointment, previous failed appointments, owning a cell phone, and distance from the hospital were significant predictors of no-shows. In a study of over 8800 obstetrics and gynecology (OB/GYN) patients, Dreiherr et al. [7] used a logistic regression model to investigate patients' characteristics that were correlated with no-shows. Their study revealed that factors such as age, population sector and waiting time for an appointment significantly impacted a patient's decision to miss his/her appointment.

Qualitative factors may affect a patient's decision to miss his/her appointment as well. For instance, in a study of 536 patients within

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a periodontal clinic, Herrick et al. [8] found “forgetting” about the appointment was the most frequent reason given for no-shows. Their research showed that losing one’s appointment card and showing on the wrong day were also significant and accounted for 51.4% of the appointment failures. Other significant factors included having a telephone and an automobile. In a study of outpatients in an urban family practice setting [9] participants identified three types of issues related to missing appointments without notifying the clinic staff (i.e., canceling the appointment). These issues included emotions, perceived disrespect, and not understanding the scheduling system. Deyo and Inui [4] reported that the most frequent qualitative reasons cited in the literature include patient forgot the appointment; patient did not know about the appointment; and patient misunderstood the appointment. Other factors reported include lack of transportation, a sick person at home, or not enough money.

This study focuses on quantitative factors that contribute to no-shows. We first attempt to confirm the results of some of the extant research and show that certain patients’ characteristics are significantly associated with attendance. We then develop a predictive model for patient scheduling based on decision tree analysis. Our study expands the earlier research by assessing the relative predictive powers of four different decision tree techniques as well as those of a Bayesian networks and a neural networks models. Further, the tradeoff between the complexity of the classification rules (tree size) and the overall prediction power of the final model is investigated using full-sample testing as well as split-sampling. Lastly, we use computer simulation to assess the impact of various levels of overbooking on the clinic’s utilization when using schedules based on the predictive model.

Organization of the paper is as follows. Section 2 presents the problem definition followed by solution approach (Section 3). Development of the predictive model is presented in Section 4 followed by the discussion of the results (Section 5). Section 6 presents conclusions and areas of future research.

2. Problem definition

The University of Michigan-Flint Urban Health and Wellness Center (UHC) is an outpatient specialty clinic. It was founded in 2003 with the mission of providing care to the medically underserved. The Physical Therapy (PT) Clinic within the UHC was established in May of 2006 and currently provides services to medically underserved adults (ages 19–64) from the Greater Flint area. The Clinic serves residents from Genesee County who are members of the Genesee Health Plan (GHP), a locally administered medical health plan covering primary care and physical therapy expenses for otherwise uninsured individuals. Twenty-six thousand (26,000) members are currently enrolled in the GHP county-wide. The PT Clinic is open Monday through Friday, 8:00 a.m. to 4:30 p.m. with one hour of closing from 12:00 p.m. to 1:00 p.m. for lunch breaks. At present, only patients with chronic musculoskeletal pain conditions, and pre and post-orthopedic surgical patients are treated. Appointments are made by contacting the front office medical assistant staff directly. The Clinic utilizes a commercial information software package for all scheduling and data management.

The Physical Therapy Clinic has experienced significant no-shows since its opening, resulting in challenges in determining appropriate staffing levels as well as causing relatively large financial losses. The Clinic operates on a fee per visit basis and cannot bill the plan when a patient does not show for a scheduled appointment. There is no financial penalty for the patient associated with missed appointments. Because the full time clinicians are salaried employees, patients’ no-show negatively affects

productivity and profitability. Another issue related to no-shows is relatively longer waiting periods for an appointment. Because physical therapists spend approximately 30 min with each returning patient, the Clinic has a limited capacity with respect to the number of patients that can be scheduled in a given day. Therefore, patients’ no-show has negatively affected the Clinics ability to schedule patients for their first and subsequent appointments. Waiting period for a first appointment can vary from a few days to many weeks depending on the number of patients scheduled and cancellations. Some patients call the Clinic staff in advance to cancel their appointments. In such cases, it is possible to a call other patients with a future appointment and offer to fill the newly available timeslot. However, a large percentage of patients simply miss their appointments and it is not always possible to find another patient available and willing to take the open timeslot. Clinic records show that the typical monthly no-show rate is approximately 16% for all patients and 21% for new patients while the cancel rate (patients notifying the clinic in advance) is approximately 22% for all patients and 27% for new patients.

Due to potential safety issues as well as reimbursement restrictions clinicians generally provide care on a one-on-one basis. The clinic has recently attempted three ad hoc approaches to try to offset the negative effects of the relatively high no-show and canceling patients. This has included reducing certain patients’ appointment times from 30-min to 15-min, scheduling new patients only in the afternoon, and calling each patient the night before a scheduled appointment. The reason for scheduling new patients in the afternoons is they require undertaking a complete history interview followed by a physical exam which normally takes about 45 min. Returning patients prefer morning appointments therefore the Clinic is not as busy in the afternoons. These approaches have been used based upon the management and clinician past experiences and not on any prior analyses of patients’ records or other evidenced-based processes. Because the provision of physical therapy services requires direct clinician–client interaction, challenges as mentioned above arise when several scheduled patients actually show up on the 15-min time frame. Hence, a reliable procedure is needed to estimate the probability of show for patients who are scheduled too close to one another which is a form of overbooking. This will allow the scheduler to avoid overbooking patients with a relatively high probability of show. It will also allow the scheduler to implement a targeted overbooking of patients with high probability of no-show, minimizing the expected number of unused timeslots due to no-shows, thereby increasing the overall utilization of the Clinic.

Research on appointment scheduling dates back to 1950’s with the work of Bailey [10], utilizing queuing models. Rohleder and Klassen [11] used a simulation study to investigate the effects of six different scheduling rules using overloading (i.e., double booking and using overtime) in general family practice clinics. Their work assumed variable service times and exponential call inter-arrival times. Their general model parameters were obtained from interviews with two medical clinics as well as reported literature. No patient characteristics were included in the study. LaGanga and Lawrence [12] also conducted a simulation study of overbooking patients within a community mental health center. They developed a utility function that captured the tradeoffs between increased patients’ waiting time and providers’ overtime. This work was not based upon patients’ characteristics. Similarly, Muthuraman and Lawley [13] investigated stochastic overbooking in developing an appointment schedule for outpatient clinics. Their model optimizes an objective function based on patients’ waiting time, staff overtime, and patient revenue and develops a myopic scheduling policy that uses the patients’ no-show probabilities. We propose developing a scheduling procedure based on actual patients’

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