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Design and analysis of an outpatient orthopaedic clinic performance with discrete event simulation and design of experiments

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ABSTRACT

Considering that demand for healthcare services is constantly increasing, outpatient services must improve their performance. Being able to satisfy the demand with a limited outpatient service capacity is an important operational challenge. The objective of our research consists in studying the relationships and interactions between patient flows, resource capacity (number of consulting rooms and number of nurses) and appointment scheduling rules in order to improve an outpatient orthopaedic clinic performance. Discrete event simulation is used to model outpatient flows. An experimental design was developed to test how to assign consulting rooms and nurses to each orthopedist considering four appointment scheduling rules and three patient flow types of varied complexity. Analysis of variance and the Tukey test are used to evaluate the simulation results. Our conclusion is that in order to improve the outpatient orthopaedic clinic performance, resources (consulting rooms, nurses) and appointment scheduling rules must be adapted to the different patient flows.

1. Introduction

Considering a growing demand for healthcare services, it becomes essential for outpatient services to review how they do things in order to improve and increase their performance. Outpatient services such as consulting, treatments and follow-up of patients, coming through emergency or with a scheduled appointment, are often grouped together in a unique location. Being able to satisfy the demand with a limited outpatient service capacity is an important operational challenge.

In this paper we study an outpatient orthopaedic clinic located in a public medical and social healthcare center in the province of Québec (CSSS) and that uses its radiology services. Approximately 22,000 patients come to the clinic every year. This represents between 400 and 450 patients per week depending on the number of orthopedists present. The decision makers of the outpatient orthopaedic clinic are concerned by the importance of reducing patient waiting times while keeping a high proportion of occupied time for medical staff. Indeed, they are receiving many complaints about long patient waiting times.

The clinic is opened from 8h00 AM to 5h00 PM, Monday to Friday and includes six examination rooms. A total of eight orthopedists and four nurses work in the outpatient orthopaedic clinic. On Mondays, Tuesdays and Wednesdays consulting periods are reserved to specific orthopedists, two on each day. Table 1 presents the outpatient orthopaedic clinic schedule over a week. This schedule is constructed according to each orthopedist's surgery schedule.

Each consulting period is managed by an orthopedist using three examination rooms and working with two nurses. On Thursdays and Fridays only half a day is reserved to a specific orthopedist leaving the other periods free for any orthopedist wishing to use them. The weekly number of consulting rooms and nurses required by an orthopedist depend on his or her patient caseload. For instance, some orthopedists may need to be at the clinic two days a week while others may need only one day. Orthopedists' caseload is variable. For instance, an orthopedist may have to see 80 patients weekly and another one only 50. According to the orthopaedists availability, the number of patients seen each day may vary between 40 and 50 per orthopaedist. Consulting rooms and periods must thus be assigned to each orthopaedist together with nurses to assist them weekly. Since the clinic intends to hire new orthopedists soon the assignment of consulting rooms and nurses to orthopedists and the appointment schedules (rules and number of patients) need to be reviewed.

The number and the type of patients scheduled daily vary according to the number of consulting rooms and the number of nurses available. Generally each patient has an appointment with

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Table 1
Weekly orthopedists' schedules of the outpatient orthopaedic clinic.

Day	Room 1 Nurses 1 et 2	Room 2	Room 3	Room 4 Nurses 3 et 4	Room 5	Room 6
Monday	Orthopedist 1			Orthopedist 2		
Tuesday	Orthopedist 3			Orthopedist 4		
Wednesday	Orthopedist 5			Orthopedist 6		
Thursday	Free	Free	Free	Orthopedist 7		
Friday	Orthopedist 8			Free	Free	Free

a specific orthopedist and the consulting periods assigned to each orthopedist are known in advance. Appointment schedules for each orthopedist cover a three month period.

The appointment scheduling rule currently used by the outpatient clinic consists in scheduling 2–3 patients per orthopedist every 10 min with a lunch break between 11h30 AM and 12h30 PM. With this rule it is possible to schedule 57 patients per day for each orthopedist, most of them are scheduled before 11h30 AM and only a few after 2h30 PM. This schedule usually generates bottlenecks and very long patient waiting times during mornings. This is one of the reasons why more efficient appointment scheduling rules needed to be defined and tested.

Patients may follow up to three trajectories (Fig. 1). Rectangles are for process steps, arrows for patients traveling through the clinic and triangles for patients waiting:

- Trajectory 1: The patient must go to radiology before meeting with the orthopaedist. This trajectory has two steps.
- Trajectory 2: The patient only meets the orthopaedist. This trajectory has only one step.
- Trajectory 3: The patient must have his plaster removed by the nurse, go to radiology and meet the orthopaedist. This trajectory has three steps.

Data provided by the clinic show that:

- 35% of patients follow trajectory 1.
- 50% of patients follow trajectory 2.
- 15% of patients follow trajectory 3.

This is a mix flow type which is the one usually observed in most orthopaedic clinics. However percentages may differ.

The decision makers wish to reduce the mean patient lead time to less than 60 min and to determine rules for the assignment of consulting rooms and periods to host the new orthopedists. Some of the current orthopedists are afraid that improving patient lead times might reduce the daily number of patients they can see at the clinic and increase their idle time. They think that each orthopedist should be able to see at least 50 patients daily, if they wish, and that their proportion of occupied time should be at least 85%.

The objective of our study consists in studying the relationships and interactions between patient flow types, resource capacity (number of consulting rooms and number of nurses) and appointment scheduling rules in order to find a way to improve an outpatient orthopaedic clinic performance. Our research intends to verify, for orthopaedists needing more than one day weekly to see patients, if patients should be scheduled according to their trajectory. This research contributes to the literature in three ways. First, it considers and evaluates different patient flows for one process (one, two or three-step trajectories). Few papers exist on patient trajectories and on their relationship with appointment scheduling rules in the literature (Santibanez, Chow, French, Putterman, & Tyldesley, 2009; White, Froehle, & Klassen, 2011). Second, this research also takes into account resource assignment (consulting rooms, nurses), appointment scheduling rules and how they impact on the patient flows. The study of the relationship between resource assignment, appointment scheduling rules and patient flows will allow a better understanding of how to plan resources in complex systems. Finally, our model is about a real case study of an outpatient clinic which is not the case of many papers that are more theoretical (Cayirli, Veral, & Rosen, 2006; Liu & Liu, 1998; Rohleder & Klassen, 2000; Swisher, Jacobson, et al., 2001; Yang, Lu, & Quek, 1998). Our model was built with empirical data representing real service times. It takes into account orthopedists lateness and absence and walk-in patients.

2. Literature review

2.1. Appointments scheduling

Appointment scheduling in an outpatient clinic consists in determining the sequence of patients to optimize some performance measures. Many papers can be found in the literature on appointments scheduling. They can be divided into two categories: static and dynamic problems. When appointments are scheduled without the possibility to modify the schedule, it is considered as a static problem. This is how appointments are scheduled in most healthcare services. Therefore many papers are devoted to these scheduling appointment problems. When the appointment schedule can be constantly reconsidered during a given day

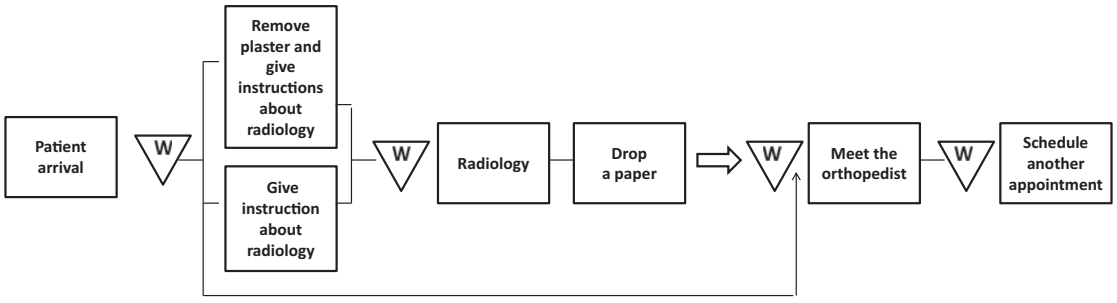

Fig. 1. Mapping patient trajectories.