

Outpatient Appointment Systems: A Review of Analytical Work

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MSOM 2015 Extend Abstract

Introduction

In the recent years, due to emphasis on preventive medicine practices, shorter hospital stays, and more services being provided on an outpatient basis, outpatient clinics have become more central in healthcare systems. The outpatient appointment system (OAS) is the most important component for efficient care delivery in outpatient clinics. The appropriate OAS enables clinics to provide delivery of care at the right time, utilize medical resources optimally, and maximize patient and physician satisfaction. For this reason, OAS problems have become an attractive research area, having been studied for more than half a century. Thus, the body of the literature on OAS studies is large, with a significant emphasis on appointment scheduling.

A review of the literature related to OAS problems, especially appointment scheduling can be found in Cayirli & Veral (2003). Their main goal was to review prior formulations and modeling considerations in outpatient services. Gupta & Denton (2008) extended this by focusing on describing the most common types of outpatient clinics with particular attention to the factors that complicate OAS and thus provide research opportunities. The current paper adds to these by updating the literature and by providing a comprehensive review of recent work in operations research that provides decision support tools to support OAS decision makers.

Organization of the review

We evaluate the OAS literature from two perspectives: 1) problem setting and environmental factors; 2) problem formulation and solution methods. To review the problem setting, we identify decisions that are made for designing, planning and scheduling OAS by investigating the literature, and divide these into three categories: strategic, tactical and operational decisions. In

addition, we distinguish between two different approaches that are used to make decisions at an operational level, namely rule-based approach and optimization-based approach. We believe this hierarchical structure helps provide an overview of appointment systems by identifying aspects of OAS that have not been studied previously. Table 1 shows the OAS decisions identified in this study.

Table 1 Classification of OAS Decisions

	Decision level	Code	Name
Design decisions	Strategic	S1	Access policy
		S2	Type of scheduling
		S3	Number of servers
		S4	Policy on acceptance of walk-ins
Planning & scheduling decisions	Tactical	T1	Number of appointments in consultation session
		T2	Panel size
		T3	Sequencing groups of the patients
		T4	Appointment intervals
		T5	Appointment scheduling window
		T6	Allocation of capacity to patient groups
		T7	Block size
	Operational	O1	Rejecting and accepting patients
		O2	Determining starting time of appointment for each patient
		O3	Determining appointment day
		O4	Selecting patients from waiting list
		O5	Allocating patients to servers
		O6	Sequencing patients

In addition, the objective functions and performance measures used are reviewed under the problem setting topic. We also discuss the various environmental factors that are considered in the OAS literature, including unpunctuality of patients, physician lateness and interruption level, patient no-shows, preferences, service time, heterogeneous patients and type of appointment. Due to the significant impact of environment factors on the complexity of OAS problems, we present a classification of reviewed papers based on these factors.

To understand the importance of operations research techniques to tackle OAS problems, the

modeling approaches and solution methods used in the literature are classified and a brief discussion based on this classification and a selection of appropriate papers is presented.

Finally, we present a detailed table of reviewed papers in terms of main assumptions related to strategic decisions, problem decision, objective function, modeling approaches and solution methods to provide a reference tool that can more easily demonstrate existing gaps in the literature.

Discussion

This review shows that although the body of research in OASs is growing, there are still a number of outstanding research questions. Some of these are summarized in Table 2.

Table 2-Summary of Outstanding Research Issues for Analytical Studies

Strategic level	Environmental factors
<ul style="list-style-type: none"> Online systems with considering stochastic future arrivals Extension of online systems Multiple server OASs Walk-ins (regular and urgent) in OASs 	<ul style="list-style-type: none"> Preemptive interruption level Heterogeneous service times Provider preferences Heterogeneous no-show probabilities Appointment series in online systems Multiple appointments in multiple medical clinics
Tactical level	Objective function and measures of performance
<ul style="list-style-type: none"> Environmental factors in determining optimal level of T1 Integration panel size decision with other OAS problems Impacts of no-show rate on optimal level of T2 Integration T4 decision with other decisions in operational level Factors influencing capacity allocation 	<ul style="list-style-type: none"> Multi-objective function problem Multiple criteria decision making Fairness, congestion objective function Indirect waiting time in objective function
Operational level	Modeling approaches and solution methods
<ul style="list-style-type: none"> OASch models for simultaneously sequencing and timing Factors influencing appointment day Dynamic waiting list 	<ul style="list-style-type: none"> Models with practical applicability Good solution procedure in term of quality and speed for nearly realistic models
Decision problem	
<ul style="list-style-type: none"> Integrated decision problem Comprehensive models with hierarchical approach 	

References

- Cayirli, T. and E. Veral, *Outpatient scheduling in health care: a review of literature*. Production and Operations Management, 2003. **12**(4): p. 519-549.
- Gupta, D. and B. Denton, *Appointment scheduling in health care: Challenges and opportunities*. IIE transactions, 2008. **40**(9): p. 800-819.