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Scheduling appointments for walk-ins

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ABSTRACT

In addition to scheduled patients, most hospitals in Japan accept walk-ins, and the reduction of the waiting times of both scheduled patients and walk-ins is one of the managerial issues that need to be tackled. Under the stochastic behavior of the consultation time and the arrival of walk-ins, the present study proposes a scheduling method that assigns a scheduled time to each walk-in at the time of arrival and guides him or her to the waiting room at his or her scheduled time. It is assumed that the consultation time window of a physician is divided into several blocks, and each scheduled patient is allocated to one of the blocks in advance. A box is introduced into each block to accommodate walk-ins. A walk-in is assigned to a box if the total workload does not exceed the maximum workload level, which is one of decision variables of the proposed method. Numerical experiments reveal that the proposed method realizes shorter waiting times for walk-ins with increased waiting times for scheduled patients and increased total idle time for the physician. The proposed method also indicates better performance than a static method that allocates a fixed number of slots to walk-ins in each box in advance.

1. Introduction

Reducing the waiting time of outpatients is one of the significant issues in hospital management. In general, to reduce the waiting times in a hospital, each outpatient is requested to obtain an appointment in advance, to arrive at the hospital at his or her scheduled time, and then to consult a physician. The stochastic nature of consultation times, no-shows, and cancellations produces a wide range of problem situations, and much research effort has been devoted to appointment scheduling problems (Cayirli and Veral, 2003; Gupta and Denton, 2008). Although the arrival of unscheduled outpatients, that is, walk-ins, produces a complicated situation in appointment scheduling, it seems that the problem of scheduling walk-ins attracts little attention in the literature. However, most hospitals in Japan accept a considerable number of walk-ins. The Department of Internal Medicine of a hospital studied by Morikawa et al. (2013) recorded that 20% of the outpatients accepted were walk-ins. The joint minimization of the average waiting time of a scheduled patient and that of a walk-in is not a simple task. In the present study, therefore, it is assumed that an appointment time is assigned to each walk-in at the moment of his or her arrival, and until the scheduled time he or she can go anywhere then return to the waiting room at his or her scheduled time. Thus, the waiting time of a walk-in is defined by the start time of his or her consultation minus the scheduled time, which is the same as that of a scheduled patient. In the waiting room, the patient with the earliest scheduled time will be called first, regardless of the types of patients waiting. Under the stochastic consultation time and the stochastic arrival of walk-ins, determining a method for assigning a scheduled time to each walk-in arriving is a research issue. Hospitals are requested to accept all walk-ins who arrive, and it is preferable to assign an appointment time near to the arrival time of each walk-in. In addition, the sequence of appointment times assigned to walk-ins is expected to be non-decreasing for the arrival times of walk-ins. In other words, a walk-in will receive a scheduled time that is not earlier than the time given to the previous walk-in who arrived. Nevertheless, it is not profitable to restrict the sequence of appointment times in non-decreasing order from the viewpoint of minimizing the waiting times of outpatients and the total idle time of the physician. For example, there is the possibility that a walk-in will be allowed to consult the physician at the time of his or her arrival if the physician is idle at that time. This condition is called a *no-wait consultation* in the present study. A no-wait consultation means that a walk-in may have the chance to receive a consultation earlier than walk-ins who arrived before him or her. Although the occurrence of a no-wait consultation may give a negative impression to other walk-ins who arrived earlier, the present study accepts the no-wait consultation to utilize the physician's precious time, assuming that this condition happens infrequently. As it is difficult to develop exact optimization procedures that consider all the factors described above, a simple workload-based method that assigns a scheduled time to each walk-in arriving is proposed in the present study. The performance of the proposed method is examined through numerical experiments.

The structure of the paper is as follows. After a brief literature

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review in Section 2, the assumptions and performance measures are explained in Section 3. The proposed procedure for assigning an appointment time to each walk-in arriving is illustrated in Section 4, and the results of the numerical experiments are reported in Section 5. Section 6 concludes the study.

2. Brief literature review

In appointment scheduling, there are two types of rules: individual appointment scheduling rules and block appointment rules (Ho and Lau, 1992). The former rules assign an appointment time to each patient, often utilizing information on the average consultation time, and are generally effective in minimizing the patients' waiting times. However, from the practical viewpoint, block appointment rules, which divide the session into several blocks and give each patient one of the starting times of the blocks, are easy to manage. The block length and the number of appointments to be accepted in a block are decision terms in block appointment scheduling. However, hospitals or physicians who accept appointment requests may already have fixed the block length, such as 10, 15, 20, 30, or 60 min. In a hospital surveyed by Morikawa et al. (2013), a physician adopts a block length of 10 min. As hospitals or physicians may be reluctant to change the block length from the current length, the present study assumes that the block length is set in advance.

In broad terms, the appointment scheduling tries to maintain at least one waiting patient when a physician becomes ready for the next consultation. It is important to avoid the physician being in an idle state, but even if there is a long queue of patients on average, zero idle time within a session is hardly achievable in a stochastic consultation environment. Thus, it is necessary to consider the trade-off between the waiting times of patients and the idle time of the physician. One well-known phenomenon that affects the idle time of the physician is no-shows. Hassin and Mendel (2008) analyze the effect of no-shows on system performance using a mathematical formulation. One countermeasure against no-shows is overbooking, that is, accepting more appointments than the available capacity at the time of the appointments, and various approaches have been proposed. A limited list of recent papers that discuss overbooking includes Kim and Giachetti (2006), LaGanga and Lawrence (2007), Lin et al. (2011), and Muthuraman and Lawley (2008). In contrast to the activeness of overbooking to counter no-shows, accepting walk-ins can be considered as a passive method to fill open slots caused by no-shows. However, if a service sector is willing to accept more walk-ins, it is also necessary to prepare several open slots for them. Therefore, adjustments for no-shows and walk-ins, as discussed by Cayirli and Yang (2014), are necessary.

Important keywords in appointment scheduling in recent years include advanced access, open access, or same-day scheduling. These words represent an advanced-access environment, in which patients can make an appointment on the morning of the day, regardless of the reason (Murray and Berwick, 2003; Murray and Tantau, 2000). A benefit of introducing the advanced-access policy is the reduction of the no-show rate, because most outpatients who make an appointment on the day do not forget their appointment. In other words, the existence of no-shows is recognized as one of the most costly sources of uncertainty in the traditional scheduling that accepts appointments well in advance (Robinson and Chen, 2010). O'Hare and Corlett (2004) report other favorable outcomes of advanced access such as the improved patient-PCP (primary care physician) matching, the improved patient satisfaction, the increased physician compensation, and the higher net gains for clinics. Even under the advanced-access policy, some appointment requests are accepted as prescheduled (Qu et al., 2007) or routine (Qu et al., 2011) appointments. These requests arrive days, weeks or months before their appointment dates, and to schedule these appointments, several slots are reserved for accepting routine appointments. The remaining slots are used for accepting short-notice (Qu et al., 2011) or advanced-access appointments, and also for accepting walk-ins (Peng et al., 2014). The allocation of available slots for these appointment requests is modeled mathematically by Qu et al. (2007), and its dynamic decision model is studied by Truong (2015). The advanced-access demand is uncertain, and if the demand is higher than the available slots, then the request will be rejected (Peng et al., 2014), or accepted under the same-day policy (Robinson and Chen, 2010). Kopach et al. (2007) indicate that it is also necessary to develop overbooking policies in realizing successful advanced access under the simulated environment. The optimization of appointment times under multiple patient classes is discussed by Chen and Robinson (2014). They indicate that reserving the first few appointments for potential same-day patients is preferable under the condition of two types of patients: routine and potential same-day patients. Erdogan et al. (2015) also indicate that reserving the capacity at the beginning of the session for urgent patients is favorable when their waiting costs are high.

Even though many papers consider the phenomenon of no-shows in appointment scheduling, as mentioned above, the present study assumes that all scheduled patients arrive at the hospital punctually. Instead of focusing on no-shows, the present study discusses the problem of how to handle walk-ins. In Japan, it is not uncommon for outpatients to visit a hospital without having an appointment. In addition, it is generally expected that shorter waiting times will be realized for both scheduled patients and walk-ins. Morikawa et al. (2013) investigate the effect of consultation sequencing of scheduled patients and walk-ins on the average waiting times and propose probability-based consultation priority control between scheduled patients and walk-ins. Their method involves showing the maximum and minimum numbers of patients waiting in front of a patient to support the estimation of the waiting time. However, the average waiting time of a walk-in is much longer than the average waiting time of a scheduled patient in general. To reduce the waiting times of walk-ins further, the present study assigns an appointment time to each walk-in arriving. This procedure is somewhat similar to the advanced-access policy mentioned above. However, the present study assumes that walk-ins arrive at the hospital when making an appointment. Sometimes a walk-in can receive a consultation immediately if his or her physician is in an idle condition at the moment of his or her arrival. There is also the possibility of receiving a better appointment time based on the latest waiting status. In addition, all walk-ins who arrive should be accepted. Within our limited knowledge, there is no paper that considers all these conditions jointly.

3. Scheduling environment

3.1. Assumptions

- There is one physician engaged in the morning session in a hospital. In a session, the number of scheduled patients is n_s, while the expected number of walk-ins is n_w. All the scheduled patients arrive at the hospital exactly at their scheduled times, while walk-ins arrive randomly.
- The hospital opens the reception desk at time t_s and closes it at time t_e. Walk-ins who arrive at the hospital within this interval are accepted. The physician starts the consultation at time t_c, where t_c is equal to or later than t_s.
- The session is divided into several blocks, and generally one block contains multiple slots. A slot is allocated to one scheduled patient. The length of the blocks in a session is not necessarily the same, but each block contains at least one slot. Similarly, even if two blocks have the same length, the number of slots in each block may differ. The scheduled time of a slot is given by the start time of the block to which it belongs. Therefore, if two or more slots are included in a block, the scheduled patients assigned to these slots have the same scheduled time.