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Improving same-day access in primary care

Optimal reconfiguration of appointment system setups

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ABSTRACT

A concept for the optimal configuration and capacity allocation for appointment systems in primary care is presented. It is designed to provide decision-support for primary care clinics to cope with seasonal variations in patient load in order to assure a high accessibility to health care services. The central aspect of the concept is a stochastic MILP for the determination of an appointment scheduling setup configuration, which is defined by the allocation of walk-in and pre-scheduled appointment blocks in combination with the allocation of daily service times. The tactical decision is the efficient allocation of capacity for walk-ins and pre-scheduled patients, where it has to be assured that urgent patients have sufficient access to health care services. In this paper, it is analyzed to which extent reconfigurations in the appointment system setup and incorporation of uncertainty with respect to patient load is beneficial. The main contribution is a concept determining efficient appointment systems to cope with stochastic and seasonal patient load by reconfiguring the appointment system throughout the year. A case study provides managerial insight for varying patient settings, suggesting that even with a high share of urgent patients there is a significant benefit of reconfiguring the appointment system throughout the year.

1. Introduction

Having health issues, patients typically contact their primary care physician (PCP). The PCP, as the first point in contact in the health system, examines whether there is a crucial health issue that requires a quick treatment and whether patients are referred to secondary or tertiary care [1]. Additionally, primary care provides health services for minor health issues, such as flu treatment. These services are provided right away. The need for a near-in-the-future diagnosis and treatment puts primary care in a key position in an efficient health care system. As the access to a quick diagnosis and treatment is the core need for patients with an urgent request, pre-scheduled appointments which are booked several days in advance are no option. Thus, providing timely service is one of the most important objectives in primary care [2]. For regular patients who do not have an urgent request, pre-scheduled appointments can be favored as a lower waiting time can be expected. Efficient appointment systems (AS) allocate sufficient service times for urgent patients as well as for patients who prefer a pre-scheduled appointment to match corresponding capacity with demand. Therefore, the performance of a system is first of all measured by means of the accessibility of patients to health services. The task of allocating capacity is drastically complicated due to uncertainty and seasonality in demand which can be observed on a monthly, weekly and daily level: while the demand side shows significant variations, capacity – in terms of the PCP's working time – stays unchanged. Thus, efficient AS differ significantly in busy and quiet weeks. The question arises to which extent the performance of the system can be increased by reconfiguring the AS with respect to varying situations in terms of a changed level of patient demand during days or months. A reconfiguration of the systems only seems legit if the additional administrative effort of reconfiguring the system is compensated by significantly improved patient and clinic satisfaction. This contribution analyzes the benefits of reconfiguring the system throughout the year in order to incorporate seasonality in patient demand. An extensive analysis of the marginal benefit by increasing the number of reconfigurations per year is provided. This is done by developing and applying a new stochastic MILP model on the tactical level that determines the optimal capacity and position of walk-in and pre-scheduled appointment slots. The model incorporates the most challenging aspects of patient demand in terms of seasonality, uncertainty and varying patient settings and significantly improves accessibility. A case-study is applied in order to answer the following research questions:

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- How can an efficient appointment system setup consisting out of *pre-scheduled appointment slots and daily service times for a week* be determined?
- How often and when should an appointment system setup be adjusted?

2. Literature on determining the appointment system setup

Decision support for determining an efficient appointment system (AS) is a well-known planning problem in literature. As the paper at hand focuses on primary care, only approaches with the same decision framework will be discussed.

In accordance with Hulshof et al. [3], primary care clinics face similar planning problems with respect to capacity planning as outpatient clinics since care is provided without offering a bed or a room to stay. For a recent thorough literature review on analytical and numerical optimization studies for outpatient AS, it is referred to [4]. While Gupta and Denton [5] present an overview of the most challenging factors for the appointment scheduling planning, the focus in Cayirli and Veral [6] lies on developing a generalized problem formulation by identifying the most important model considerations from prior work. Decisions on AS are typically divided into strategic, tactical and operational planning levels:
On the strategic level, overall capacity is determined by the size of the clinic with its number of servers. Strategic decisions are included as input parameters most of the time, rather than being determined within the optimization model [4]. *On the tactical level*, the clinic profile setup is derived [7]. Ahmadi-Javid et al. [4] divide the decisions on the clinic profile setup into allocating capacity to patients groups (such as pre-scheduled and walk-in patients) and determining strategies for the configuration of handling of pre-scheduled appointments. An optimal setup considers the resource utilization as well as the accessibility of treatment services for all patient types. *On the operational level*, individual patients are scheduled to certain slots as in Balasubramanian et al. [8]. It is this planning level where information of the individual request is processed in order to determine an optimal allocation of patients to servers as well as the appointment day and time. Since the paper at hand focuses on the tactical planning level, relevant literature dealing with tactical decisions on the AS will be presented and delimited to this contribution in the following.
Tactical decision support
On the tactical level, overall capacity and an overall demand is given. Thereby, patients' as well as clinics' objectives have to be taken into account by focusing on partly conflicting objectives. In contrast to specialized clinics, in primary care patients' preferences are especially important [5]. It is the aim to allocate resources in a way that patients with an urgent need are seen by a server on the very same day [9,10]. If primary care clinics operate with only one physician as a server, there is little flexibility in providing health services. The decision is to configure a weekly setup (we will refer to it as an AS setup throughout this contribution), which is defined in the following as the *allocation of walk-in and pre-scheduled appointment blocks*, in *combination with the allocation of the service time provided* by the clinic on each day. The allocation of the service time throughout the week is done on a tactical level. An efficient AS setup will be defined as a solution, which utilizes the limited resources of a PCP, namely the working time, where the objectives are achieved in the best possible way. Therefore, the criteria in order to evaluate a AS setup are discussed below.

Since a primary care clinic acts mostly as the first point of contact with patients who might have serious health issues, the same-day access is one of the most crucial performance criteria. The number of same-day requests for which no care service can be provided will be defined as *overflow patients* [11]. This performance measure is not only important from a patient perspective but also for the clinic, as patients might not visit a clinic twice which cannot guarantee an adequate access to health care services. Several contributions consider generated revenues from the number of served patients as in [5,12]. Thus, a *sufficient access is the key task of an efficient AS* for patients' as well as for clinics' objectives. Besides considering the aspects of overflow patients, several other criteria – which have a lower priority – such as direct and indirect waiting time and matching of patients' preferences to a certain physician can be taken into account. It is referred to [6] for a detailed discussion of patients' preferences. Besides the number of treated patients, other clinics' preferences have to be taken into account which do not necessarily go along with patients' objectives [13].

In Wiesche et al. [11], a deterministic MILP model is presented which determines the optimal number and position of pre-scheduled appointments throughout the week in order to match capacity with demand. Such an allocation of varying capacities for pre-scheduled appointments is called interday appointment scheduling and can be utilized to incorporate varying patient loads throughout the week. It is shown that *interday appointment scheduling* is suitable for smoothing weekly patient load and clinics capacity. This idea of interday scheduling is promising as – to a certain extent – patient arrivals in the clinic can be controlled, enabling a balanced utilization as well as a significant decrease of overflow patients. Systems which allocate pre-scheduled appointment slots on certain days in a week are beneficial to cope with intra-week seasonality, which typically can be observed in primary care as identified and anticipated in [5,14] and [15]. The formulated model from Wiesche et al. [11] is adopted in this contribution and extended by seasonal and stochastic aspects which will be discussed in the following.
Incorporating seasonal and uncertain patient load
Beside the day-to-day variation over one week, there are significant seasonal effects throughout the year leading to varying average demand on a weekly basis as analyzed in [5,16,17]. Even though seasonal demand is a typical observation for health care services, it has not received much attention [16]. In Schacht et al. [18], the limits of interday appointment scheduling are evaluated. If overall demand is very high, pre-scheduled appointment slots are not sufficient to shift enough patients from busy to less frequented days. Rohleder and Klassen [19] state that the varying load leads to a constant mismatch between capacity and demand. It is analyzed that varying patient demand results in varying policies which goes along with [16]. In Cayirli and Gunes [16], a detailed description of walk-in seasonality for outpatient clinics is presented. The contribution investigates whether seasonal reconfigurations are worth the extra complexity in administration. The positive effects of adjusting the AS on a monthly basis are shown. Focusing on primary care, where simple AS are favorable and no complex booking systems are utilized, the question arises, how often an AS setup should be reconfigured throughout the year.

This contribution builds upon the findings of Cayirli and Gunes [16] with respect to adjusting the AS setup and additionally aims at answering the question of *how often* and *when* the AS setup has to be adjusted throughout the year. Therefore, the presented static deterministic MILP model from Wiesche et al. [11] is extended to a stochastic model that incorporates the dynamic development of seasonal demand.

3. Planning problem of efficient AS setup reconfigurations

This section presents a concept that allows to determine the optimal AS setup reconfigurations for a whole year. At first, a description of the important characteristics of the patient load is provided.

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