Theoretical and Practical Aspects of Outpatient Clinic Optimization

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Abstract The outpatient clinic is one of the most important departments of the hospital. Since most elective care trajectories start here, with a consultation between a care provider and a patient, the outpatient clinic functions as a gate to enter the hospital. Outpatient care is evolving rapidly around concentration of low- and high-complex care and the digitization of care processes, thus introducing new challenges in the organization of care. In this chapter we introduce the concept of access and waiting time, briefly discuss outpatient clinic capacity management, study the planning and control framework in place, and discuss Operations Research models for outpatient clinic optimization, specifically those for patient flow analysis and appointment planning. We conclude this chapter with lessons learned during the implementation of our work and discuss current challenges in outpatient clinic management. We specifically aim to support the researcher who is starting in this field, by providing a comprehensive overview of the theoretical and practical aspects of outpatient clinic optimization.

1 Introduction

The outpatient clinic is one of the most important departments of the hospital. Since most elective care trajectories start here, with a consultation between a care provider and a patient, the outpatient clinic functions as a gate to enter the hospital. Outpatient care is evolving rapidly around concentration of low- and high-complex care and the digitization of care processes, thus introducing new challenges in the organization of care. In this chapter we introduce the concept of access and waiting time, briefly discuss outpatient clinic capacity management, study the planning and control framework in place, and discuss Operations Research models for outpatient

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clinic optimization, specifically those for patient flow analysis and appointment planning. We conclude this chapter with lessons learned during the implementation of our work and discuss current challenges in outpatient clinic management. We specifically aim to support the researcher who is starting in this field, by providing a comprehensive overview of the theoretical and practical aspects of outpatient clinic optimization.

1.1 The Outpatient Clinic: The Gate to Elective Hospital Care

Since the majority of acute patients are admitted through the emergency department and receive immediate treatment, this type of patient flow is usually not present at outpatient clinics. The elective outpatient clinic visits take place in the diagnostic phase and at a later stage for treatment and follow-up consultations. Optimization of outpatient clinic care requires state-of-the-art capacity management, focusing on outpatient clinic capacity and resource management and integration with other departments such as the operating rooms, cath lab, and inpatient wards.

While the interaction with other departments is on tactical level, on an operational level there is a high interaction with other outpatient clinics and diagnostic facilities. Well known examples are that of surgical outpatient clinics with pre-anesthesia evaluation clinics and radiology departments, where the patient visits the other facilities directly after the outpatient clinic or leaves and then returns at a later point in time. Traditionally each elective care trajectory starts with a physical consultation and usually involves several outpatient clinic visits. Due to the transition of low-complex care to the GP setting, and e-health applications such as home monitoring, where the patient can be closely monitored from home and only visits the hospital if required, this typical organization of outpatient care is subject to change. Capacity will be redistributed among those patients who need it the most; at the same time the care provider activities will be focused increasingly on providing digital patient care. The COVID-19 pandemic has been a catalyst for these changes.

1.2 Crucial Concepts: Access and Waiting Time

First we introduce two concepts which are essential for outpatient clinics: access and waiting time. Access time is defined as the time between the day of the appointment request and the appointment date, while waiting time is defined as the time between the physical arrival at the facility and the start of consultation and/or treatment [16]. Access time is usually measured in days or weeks; waiting time is measured in minutes or hours. Both can vary between patient groups and depend highly on the match between allocated capacity and patient demand and the ability to deal effectively with fluctuations in both entities. Outpatient clinics often have long

access times and low utilization at the same time, albeit for different patient groups. Quotes such as *"the waiting list is too long"* or *"the clinic is overcrowded"* are therefore too general.

Waiting lists are often quite intangible, and their reliability can be questionable. They exist in several forms: an order list in the hospital information system, one or several Excel spreadsheets, on paper, in an email program, etc. It is not always the case that patients on the waiting list are not planned for an appointment yet; it can also be that their access time is prolonged (i.e., it is longer than desirable from a medical – and sometimes economical – point of view), while they already have an appointment date set.

1.3 Outpatient Clinic Capacity Management

Optimal alignment between patient demand and outpatient clinic capacity is essential, maybe even more than for other hospital departments, since often it is not yet clear what the patient's diagnosis and thus the associated risk are. When treatment is delayed, the patient may choose another care provider. Also, the patient's health condition may deteriorate which is a serious risk [24]. Patient no-shows and healthcare provider availability influence this delicate equilibrium, and thus proper capacity management, starting at strategic level and working through the tactical to the operational level, is crucial. We will elaborate further on this in the following sections.

Even though patient flow performance is better in hospitals that employ integrative practices, such as sharing waiting list and planning information, planning over several departments, and offering combination appointments, the overall level of integration in hospitals is usually low [7]. Currently, there is an increased focus on the link between the production levels on the outpatient clinic and the (elective) OR. However, integration of the planning processes from different departments is challenging for hospitals [8]. In literature, two-departmental interactions have been studied to a certain extent, but only a few studies relate to the interactions in the hospital as a whole [14, 29]. The ambiguity of patient care trajectories [29] and the segmented organizational structure of health care delivery [14] are identified as possible causes for this gap in literature. For the reader who wants to gain a deeper understanding of the organizational structures in hospitals and the logistic processes involved, we refer to [11].

2 Planning and Control of Outpatient Clinics

The design and organization of processes is known as planning and control [14]. In this chapter we focus on the managerial function of outpatient clinic capacity planning as defined in [12]. Planning and control decision-making in

healthcare comprises four hierarchical levels: the strategic, tactical, offline, and online operational level [12]. A short description of these planning levels and the planning decisions involved follows in the next paragraphs and is based on [14].

2.1 Strategic Planning

Strategic planning involves structural decision-making on a long time horizon (typically 1 year or more) and is based on aggregated data and forecasts. For outpatient clinics, this involves:

- **Regional infrastructure:** create an infrastructure in order to provide accessible outpatient care in an efficient manner by determining the amount, size, and location of outpatient facilities in a certain region.
- **Patient types (or *case mix*):** determine the patient types and related volumes, for example, based on characteristics such as disease, diagnosis, severity, acuity, or age, which will be served by the facility.
- **Capacity dimensions:** determine how many resources (local infrastructure, equipment, staff, and consultation time) are required to meet the demand for each patient type. This highly depends on the desired service levels for performance indicators such as costs, patient's access and waiting time, and provider idle time.
- **Facility layout:** decide on the layout for the outpatient clinic, given the resources required. A typical outpatient facility has at least a waiting room, reception desk, and consultation/examination rooms.

2.2 Tactical Planning

Tactical planning translates the decisions made on the strategic level to the requirements needed to execute the healthcare delivery process, i.e., the *what, where, how, when, and who*. The time horizon is typically 3–12 months. Important challenges in the organization of outpatient care are:

- **Care pathways:** for each patient type, determine the entire care pathway (sometimes referred to as *clinical pathway*) and relationships among the phases within the care pathways and in between the different care pathways. This also comprises visits and treatment at other hospital departments. Try to influence performance indicators such as length of the care trajectory, waiting and access time, and size of the waiting list by creating synergy among patient groups. This can, for example, be accomplished by combining multiple visits on a single day or mixing several patient groups in order to optimize resource utilization.
- **Fixed and flexible capacity:** determine which amount of capacity (typically 20–40%) should be used flexibly, so that fluctuations in patient demand can be accounted for.

- **Waiting list management:** determine which patient groups should be prioritized, determine acceptable access times for each patient group, and decide if walk-in or advanced access policies can be implemented at the facility.
- **Appointment schedules:** develop blueprints providing specific times and dates for patient consultations. The following key decisions design an appointment schedule [14]:
  - Number of patients per consultation session
  - Patient overbooking
  - Length of the appointment interval
  - Number of patients per appointment slot
  - Sequence of appointments
  - Queue discipline in the waiting room
  - Anticipation for unscheduled patients
- **Staff scheduling:** determine the staff shifts required and the number of employees to be scheduled on each shift.

2.3 Offline Operational Planning

Offline operational planning relates to the short-term (1 day–3 months) decision-making related to the scheduling decisions made on an individual level, given the elective demand that is known at this point in time:

- **Patient assignment:** schedule individual patients to appointment slots. This can be single appointments, combination appointments, or a series of appointments.
- **Staff assignment:** schedule individual staff members to particular shifts.

2.4 Online Operational Planning

Online operational planning comprises the control mechanisms required to deal with unplanned events, such as delay or urgent patients. The time horizon is 0–24 h. On this level, only decisions regarding unplanned events are made:

- **Patient reassignment:** reschedule patients in order to handle unplanned events, such as delay, equipment failure, staff unavailability, or incoming acute patients. The new appointment can be on the same or on a different day.
- **Staff reassignment:** reschedule staff in order to handle unplanned events, such as those defined above.

3 Operations Research Models for Outpatient Clinic Optimization

The outpatient clinic was one of the first hospital departments studied by Operations Research scholars [27, 31]. Within the literature considering outpatient clinic optimization, five main subjects can be distinguished:

1. Patient flow analysis
2. Appointment planning
3. Panel sizing
4. No-show modeling
5. General organizational improvements

Patient flow analysis and appointment planning have been extensively studied and are therefore discussed in the next two paragraphs. The latter three subjects usually do not specifically use Operations Research models but are highly related to the development of Operations Research models for outpatient clinics: panel size and the no-show rate can be input parameters, while the general organization of the outpatient clinic defines patient flow and the appointment system used.

Panel sizing is an important topic in mainly the USA and considers defining the population of patients who receive their care from a specific outpatient clinic [25]. Panel size, together with the number of appointments offered per day, determines patient access and waiting time to a high extent [32].

Patient no-shows influence clinic occupancy and financial results [13], and therefore it is important to be able to predict [4, 21] and influence [23] this behavior.

General organizational improvements relate to the mapping of patient flows and other processes and the subsequent identification of possible measures to improve operations. Principles from the Lean methodology are often used in projects like these [5, 20]. Note that a thorough analysis of processes is usually required preceding the Operations Research modeling.

3.1 Patient Flow Analysis

Simulation modeling is widely used to study patient flow problems at outpatient clinics. The famous Bailey-Welch rule [31] was derived using Monte Carlo simulation (see also Sect. 3.2). Since then, discrete event simulation has been the predominant approach (see, e.g., [9, 15, 33]). Setting up a simulation model requires detailed information on input distributions (e.g., of consultation length or patient arrivals), and building the model can be time-consuming. The possible level of detail, however, allows to model any system characteristic, such as opening hours, staff schedules, and appointment schedules. On the contrary, a queuing model requires fewer data and provides a robust insight in the underlying relationships of a system [34]. The choice to use either a simulation or queuing approach depends on

the question at hand but also on the skills of the researcher. This probably explains why examples of queuing theory applications in outpatient clinics are scarce. A recent review on queuing theory applications in healthcare can be found in [17].

3.2 Appointment Planning

Since the appointment system determines outpatient clinic organization to a high extent, appointment planning is the main topic studied in the Operations Research literature (see, e.g., [1, 3, 10, 14, 18, 22, 26] for reviews on this topic). Note that, despite all research done in the last two to three decades, the Bailey-Welch rule introduced in 1952 [31] is still used by many healthcare organizations to set up their appointment schedule. The Bailey-Welch rule implies that the first and second patient are both scheduled in the first slot, while subsequent patients are scheduled one at a time in the following slots. The Bailey-Welch rule is easy to implement and works well to prevent provider idle time during the first slots of the appointment schedule. However, it is very provider focused, since all but the first patient treated experience upon arrival already a waiting time of one slot. Examples demonstrating how to design advanced appointment schedules balancing several factors such as patient access time, waiting time, and provider idle time are given in this section. Following the planning complexity levels introduced in chapter "A Survey of Literature Reviews on Patient Planning and Scheduling in Healthcare" of this book, we discuss three types of patient planning in outpatient clinics: single appointment planning, multidisciplinary appointment planning, and care pathway planning.

3.2.1 Single Appointment Planning

In single appointment planning, appointments are planned for a single patient, one by one, on a single resource. Even though this seems relatively simple, the interference of an appointment with appointments for other patients on the same resource increases the complexity significantly. An example of this interdependence can be found in [16], which discusses appointment schedules for clinics where patients are seen both on walk-in and appointment basis.

When designing appointment systems, there are two different allocation processes to consider: (1) the distribution of patient demand over available capacity in advance and (2) the appointment process during the day. OR models usually focus on the appointment process (see, e.g., [28] and [34]) or on an a combination of both the distribution of patient demand and related appointment schedules (see, e.g., [6], [16], and [32]). The allocation process determines the uncertainty modeled in patient arrivals and consultation length, plus the performance measures studied (Table 1).

Note that the stochastic features of the appointment process influence clinic capacity as well.

Table 1 Uncertainty in patient arrivals and consultation length, plus the performance measures studied for both allocation processes

Allocation process	Patient arrivals	Consultation length	Performance measures
Distribution of patient demand	Stochastic	Deterministic	Patient access time; clinic utilization
Appointment process	Deterministic (stochastic when considering walk-in or urgent patients and no shows)	Stochastic	Patient waiting time; provider idle time; overtime; clinic utilization (on day and/or provider level)

3.2.2 Multidisciplinary Appointment Planning

In multidisciplinary planning, coordinated packages of care are planned for a single patient. This can either be a single activity on multiple resources or multiple activities on single or multiple resources [30]. Since the trajectories of care that need to be planned usually vary in both duration, and in the number, frequency, and type of appointments to be planned, focus is on the planning process and not so much on the performance of the appointment system during the day. See, e.g., [2].

3.2.3 Care Pathway Planning

Care pathway planning is in many ways similar to multidisciplinary planning. The main difference is that care pathways are designed to exactly specify the care trajectory for an entire group of patients, while multidisciplinary trajectories are specified for a single patient. Since multiple patients receive the exact same care trajectory, care pathways reduce the process variability and thus the planning complexity [29]. However, care pathways are notorious for complicating the planning for other patients, i.e., those who are not within the care pathway [35]. Instead of designing complicated planning systems, it is sometimes better to decrease access time for all patients. Related to this is the concept of advanced access [24], by "doing today's work today."

4 Lessons Learned from a Case Study

In this section we discuss the practical aspects of a project, where we redesigned an anesthesia evaluation outpatient clinic. This project was carried out in Leiden University Medical Center (LUMC), a tertiary referral hospital in Leiden, the Netherlands. A detailed description of the project, the mathematical modeling involved, and the results can be found in [34].

Preoperative screening, where patients are reviewed from an anesthesiological perspective prior to elective surgery, is usually organized in an outpatient setting. In this case study, a project carried out at the pre-anesthesia evaluation clinic (PAC)

of LUMC is described. When the study was conducted, 6,000 patients visited the PAC annually, of which about 70% were served on walk-in basis (i.e., without an appointment). These concerned mainly low-complex patients, while medium- to high-complex patients (10%) were usually given an appointment. The other 20% of patients that were seen on appointment basis initially visited the clinic as a walk-in patient, but at the moment of their arrival the clinic was overcrowded, and thus they were sent home with an appointment. The advantages of offering walk-in service are a higher level of accessibility and freedom for the patient to choose the moment of the hospital visit. Disadvantages are variability in demand and usually low utilization rates and long waiting times [16]. PAC management insisted on maintaining the walk-in option but was aware that from an organizational point of view a couple of improvements were necessary, namely, (1) reduce patient waiting time; (2) reduce the frequency and intensity of overcrowding (which has a direct relationship with variability in patient demand); and (3) reduce the time between the PAC consultation and the anesthesiologist's approval for surgery.

At the start of the project, a working group was set up with representatives from all employee groups working at the PAC (anesthesiologists, nurses, clinic assistants, and the secretary). The working group was supported by a mathematical analyst and chaired by the clinic director (an anesthesiologist). The initial design and its bottlenecks were discussed in several sessions by the working group. To eliminate bottlenecks, the working group commonly developed four alternative clinic designs which were evaluated using a multi-class open queuing network model. The results of the evaluation of the designs were extensively discussed in the working group. If necessary, it was possible to implement small changes in the model (like parameter values), such that changes proposed by the working group during the project meetings could be evaluated directly. The working group unanimously decided to implement a new clinic design, for which the queuing model predicted this would result to better overall performance of the clinic. After implementation, actual measured times of total patient length of stay before and after the intervention were compared. While the total length of stay did not significantly change, an unexpected increase in the number of patient visits of 16% was reported. It can be concluded that a considerable growth in patient inflow did not result in worsened performance.

Looking back, there are a couple of lessons we learned from this case study which we would like to share. Setting up the working group and using a (mathematical) model, which could be used for instant evaluation of different alternative clinic designs and parameter/variable settings, were very useful. The use of the model decreased the subjectivity in the discussions and led the team away from pinpointing to specific individuals. Instead, employee roles and challenges associated with the setup of these roles were discussed, which was very valuable. Also, the involvement of the mathematical analyst, an unbiased individual without any prior relationship with the problem or the team, was very useful and improved the quality of the working group discussions. The implementation of the clinic redesign was quite smooth, probably because its possible (positive and negative!) effects were thoroughly analyzed and discussed.

There were also a couple of points for improvement. The KPIs which were set by management were clear, but targets were missing on the desired reduction in waiting

time, overcrowding, and time between the PAC consultation and anesthesiologist's approval. This made it difficult to evaluate the project's results afterward. When would it be good enough? Also, the implemented organizational change (i.e., the redesign) was not locked in: it was too easy to return to the initial design, which happened about 2 years later when a minor change in the workflow was effectuated, even though this resulted in prolonged waiting and access times for patients. Thus in the end, the intervention was not secured.

5 Current Challenges in Outpatient Clinic Management

The world inside and outside of the hospital is changing rapidly. Overcrowding of waiting rooms is even more undesirable than it was before, making a well-designed appointment system an important asset in outpatient clinic management. One can think of several measures to decrease overcrowding, while patient access increases. Factors that influence the number of patients present in the waiting room are patient inflow, throughput, and outflow. For each category possible measures are given in Table 2.

Table 2 Possible measures to influence patient access and clinic presence

Category	Measure	Description
Inflow	Distribution of consultations	Distribute consultations evenly over the day and the days of the week
Inflow	Digital consultations	Provide digital consultations for patients who require minimal physical examination or for whom the physical examination can be substituted by an (technological) innovation
Inflow	Home monitoring	Provide home monitoring applications in order to provide immediate access when the patient's condition deteriorates, while the patient does not need to visit the hospital when his/her condition remains stable
In- & outflow	Low-complex care by GP	Allocate low-complex treatment of patients to the GP in order to avoid hospital visits and medicalization of health status
Throughput	Additional waiting rooms	Use empty consultation rooms as waiting room to avoid overcrowding in the regular waiting room
Throughput	Consultation preparation	Prepare the consultation thoroughly by providing questionnaires, pre-diagnostics, and information about the consultation and treatment, in order to improve the consultation's outcomes and avoid additional consultations
Outflow	Shared decision-making	Use shared decision-making to determine, together with the patient, what the best treatment options are. The overuse of treatment is likely to decrease [19], thus decreasing the demand for outpatient clinic capacity

The increased usage of digital health applications requires different skill sets from hospital staff. While most of these initiatives are currently run from behind the counter in both in- and outpatient settings, a trend toward clustering in centers outside of hospitals is emerging. This shift in the organization of work, which was until very recently the domain of outpatient clinic staff, will have an enormous impact on the organization of outpatient clinics. Operations Research modeling can be of great value here.

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