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Integral multidisciplinary rehabilitation treatment planning

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ABSTRACT

This paper presents a methodology to plan treatments for rehabilitation outpatients. These patients require a series of treatments by therapists from various disciplines. In current practice, when treatments are planned, a lack of coordination between the different disciplines, along with a failure to plan the entire treatment plan at once, often occurs. This situation jeopardizes both the quality of care and the logistical performance.

The multidisciplinary nature of the rehabilitation process complicates planning and control. An integral treatment planning methodology, based on an integer linear programming (ILP) formulation, ensures continuity of the rehabilitation process while simultaneously controlling seven performance indicators including access times, combination appointments, and therapist utilization. We apply our approach to the rehabilitation outpatient clinic of the Academic Medical Center (AMC) in Amsterdam, the Netherlands. Based on the results of this case, we are convinced that our approach can be valuable for decision-making support in resource capacity planning and control at many rehabilitation outpatient clinics. The developed model will be part of the new hospital information system of the AMC.

1. Introduction

Rehabilitation clinics treat patients recovering from injury, illness or disease. Patients require a series of treatments administered by therapists from various disciplines, such as physiotherapy, occupational therapy, social work, speech therapy, and psychology. According to the recent World Health Organization (WHO) report on disability [1], in high-income countries about 18% of the population lives with some form of disability, and the prevalence of disability is rising due to aging populations and the global increase in chronic health conditions. The expenditures for rehabilitation care have substantial pay offs including enhanced economic activity, health outcomes, educational achievements, and participation in community activities of people with disabilities [1]. Public spending on disability programs amounts to 1.2% of GDP for OECD countries and is particularly high in the Netherlands and Norway, where expenditures on disability account for approximately 5% of GDP [1]. The WHO [1] indicates improvement potential of rehabilitation care both in terms of quality and efficiency.

Because rehabilitation care is a multidisciplinary process, coordination within both the care process and the logistical organization is essential [2,3]. As in many health care processes, and rehabilitation in particular, planning deficiencies have a negative impact on both the quality of care and logistical efficiency [1,4]. The multidisciplinary nature of the rehabilitation process complicates planning and control. Naturally, the best quality of care is realized when the right treatments are provided at the right time [5]. Rehabilitation care professionals indicate that a short access time [6], a simultaneous start with the various disciplines, and the continuity of the rehabilitation process should be guaranteed. In addition, the complexity of rehabilitation care carries the risk of both undertreatment and overtreatment [7]. Despite the positive cost-effectiveness ratio of current rehabilitation care, both the WHO [1] and a recent improvement program for the Dutch rehabilitation sector [8] observe a large potential for rehabilitation care to be organized more efficiently and effectively. This paper connects with this improvement potential by presenting a planning methodology that enables the integral planning of multidisciplinary treatment plans. The effectiveness of this planning methodology is demonstrated by its application to a case study in the Academic Medical

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Center (AMC), a Dutch university hospital. Considerable enhancements in patient-centeredness, quality of care, and efficiency are achieved. By implementing the methodology, more patients can be treated with the same therapist capacity, and patients benefit from both a higher quality of care and a higher quality of service.

From the WHO report [1], we can conclude that the setting of the AMC rehabilitation clinic, and its organizational difficulties and logistical issues, are typical of rehabilitation care in general. In current AMC practice, several factors hinder the planning and control of rehabilitation care; of these factors, two main drivers are that planning is decentralized and that computerized support for the planning task is limited. All disciplines, or even therapists, manage their own agendas. Planners are supported by an electronic calendar system. However, the current state of this system comprises a database system that lacks the intelligence of a decision support system (see Section 3 for a more detailed discussion). Consequently, in many cases, a short access time and a so-called 'simultaneous start' cannot be realized. Moreover, the timely planning of follow-up appointments can be problematic, which can cause a discontinuity in the rehabilitation process. As a result, certain prescribed treatments may never be realized because they cannot be scheduled. In addition, outpatients have to visit the clinic more often than required, because appointments are spread out over several weekdays instead of combined into a single day. Concerning the system's logistical efficiency, planning deficiencies result in the suboptimal utilization of the valuable time of the therapists. We address these issues by developing a model for planning a series of appointments.

We identify three steps for improving a rehabilitation outpatient clinic's organization. The first step a clinic can take is to obtain insight into the demand and the supply of their rehabilitation care [1]. Although seemingly trivial, this insight is often lacking in practice. A clear perception of demand can be acquired by constructing treatment plans (per disease type or on an individual basis) [9], prescribing all treatments that should be realized during the course of a rehabilitation process. Insight in and control over supply can be gained via centrally managed therapist schedules [10]. As a second step, automated support of the planning task can yield further improvements [1,11]. A first requirement of a software tool is to enable planners to identify feasible planning proposals for individual patients based on their prescribed treatment plans [8]. Using such a decision support tool, the utilization of therapists could be made clear in an earlier stage, thereby enhancing the planning and control of this precious resource. In a third step, by exploiting operations research techniques, intelligent planning algorithms can be developed and implemented in the software tool to find planning proposals that are efficient for both patients and clinicians. Such tools also permit the evaluation of multiple planning strategies and provide a basis for rationalizing the required number of therapists, aligning therapist agendas, and determining the desired patient mix [12].

The present paper specifically addresses the third step noted above, as we present a method for planning series of appointments for rehabilitation outpatients based on an integer linear program (ILP). Using an ILP, multiple performance indicators are formulated for planning and are weighted according to a uniform strategy. As we have developed the planning methodology to support the rehabilitation outpatient clinic of the AMC, the ILP was developed in close cooperation with the rehabilitation care experts. Our basic approach is generically applicable to the rehabilitation sector, and the model can be customized for other multidisciplinary care facilities. The results of the AMC case demonstrate the application of such models for multidisciplinary treatment planning in the rehabilitation sector to be very promising.

This paper is organized as follows. Section 2 provides an overview of the related literature. Section 3 describes the case study setting. Section 4 presents the ILP model for planning a series of appointments. The planning methodology is applied to data from one of the treatment teams within the rehabilitation outpatient clinic of the AMC. We display the numerical results in Section 5, followed by the discussion and conclusion in Section 6.

2. Literature

Appointment scheduling in health care is a topic that has received considerable attention in the literature. Two comprehensive surveys are provided in [13,14]. The literature has mostly focused on scheduling a given number of single appointments on a particular day for an individual service provider [13]. Gupta and Denton [14] identify several open challenges in appointment scheduling, prominent of which are planning coordinated packages of care for patients requiring treatment from several health services, scheduling in highly constrained situations, and incorporating patient preferences.

In this paper we consider an *online* scheduling problem, meaning that a patient issuing a planning request gets a direct response in the form of a planning proposal. *Offline* scheduling entails saving up planning requests and executing these periodically. Previous studies in rehabilitation planning consider such offline scheduling problems, either in a multidisciplinary setting [15], or for a single discipline [16–20]. Schimmelpfeng et al. [15] develop a decision support system for multidisciplinary scheduling in rehabilitation hospitals. They formulate a mixed integer linear programming model that is decomposed into a hierarchical three-stage model system to resolve computational difficulty. Studies considering a single discipline use a planning horizon of one day [16–18] or one week [19,20]. The scheduling challenge of sequencing a given set of physiotherapy treatments of multiple patients on a single day is addressed in [16–18]. Using a time horizon of a week, Ogulata et al. [19] consider selecting and scheduling outpatients for physiotherapy treatment, while Griffiths et al. [20] develop a decision support system that generates a timetable for physiotherapy inpatient treatment.

Methods have been developed for offline scheduling of appointment series for radiotherapy [4,21] and chemotherapy [22] outpatients. For these patients, radiation treatments must be scheduled during a given number of weeks, strictly taking into account the required rest periods. Conforti et al. [4,21] present an ILP for radiotherapy treatment scheduling, minimizing access times while maximizing device utilization. Turkcan et al. [22] use a two stage ILP approach for solving a similar problem. In the first stage, patients are assigned to days, and in the second stage, appointment times are given to all patients on their assigned days. The objectives are minimizing access times, treatment delays, and staff overtime. The main difference between radiotherapy treatment planning and rehabilitation treatment planning, is the single disciplinary nature of the former. In addition, the range of objectives involved in rehabilitation treatment planning is generally wider.

Considering an offline problem in a hospital-wide, multidisciplinary context, Gartner and Kolisch [23] study scheduling all the procedures of the clinical pathways of elective inpatients. The aim is to maximize the contribution margin, defined as the difference between the payments a hospital receives based on patients' diagnosis-related groups (DRGs) and the costs for treating these patients. They formulate two mixed integer programming models that assign all procedures in patients' pathways to days, taking into account precedence relations between the procedures as well as limited availability of medical resources. Gartner and Kolisch restrict their scheduling models to the level of day assignment, stating that their results can be used as input for more detailed time slot scheduling models. While inpatients experience the time between two procedures on the same day as time related to their

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