

A Survey of Literature Reviews on Patient Planning and Scheduling in Healthcare

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Abstract This chapter provides a classification of literature reviews on patient planning and scheduling decisions in healthcare. To this end, we provide a mathematical interpretation of hierarchical planning levels and then add the planning complexity dimension to an existing planning and scheduling framework, resulting in a 3D framework for patient planning and scheduling decisions in healthcare. Subsequently, we provide an overview on recent surveys and reviews on this topic and position these studies in the 3D framework.

1 Introduction

This chapter provides a classification of literature reviews on patient planning and scheduling decisions in healthcare. To this end, first we provide a mathematical interpretation of the hierarchical planning levels as defined in [9]. Second, we add the planning complexity dimension to the planning and scheduling framework as introduced in [11], resulting in a 3D framework for patient planning and scheduling decisions in healthcare. Third, we provide an overview on recent surveys and reviews on this topic and position these studies in the 3D framework.

2 A 3D Classification of Planning Decisions in Healthcare

The taxonomy of planning and control decisions in healthcare as presented in [11] has two axes. On the x-axis, services in healthcare are positioned, where we have selected ambulatory, emergency, surgical, inpatient and home care services, and

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further services may be added, while the y-axis reflects the hierarchical nature of decision-making in resource capacity planning and control as introduced in [9]: strategic, tactical, operational offline and online levels. In this section, we provide a mathematical interpretation of these hierarchical planning levels via the level of uncertainty. Subsequently, we add a third dimension to the taxonomy: planning complexity, comprised of single activity planning, multidisciplinary planning and care pathway planning. Our aim is not to provide an in-depth description of these levels of complexity as these are covered in later chapters but to illustrate the levels that are extensively covered and those that are seldomly addressed in literature.

2.1 Hierarchical Planning Levels and Uncertainty

Aligning supply of and demand for care aims for patients receiving their prescribed care at the right time, by the right professional, and at a suitable location, while staff workload is levelled, and other resources are efficiently utilised. This alignment is organised in three hierarchical planning levels: strategic, tactical and operational [9]. At the strategic level, the budget over a long time horizon (e.g. per year) is determined, which includes the total amount of available resources such as staff and rooms. At the operational level, the supply of care is known as well as the individual patients that have a demand for care; operational planning then amounts to booking a patient in available appointment time slots. Offline operational planning concerns the in-advance planning, whereas online operational planning involves control mechanisms that deal with last-minute unforeseen or unanticipated events. The tactical level is the intermediate level (e.g. a time horizon of several months) at which the available supply of care is known, but the individual patients and their demand for care are not yet (entirely) revealed. The available capacity is matched to specific activities in, e.g. a master schedule or blueprint. This planning level is often overlooked in healthcare and is tantamount to an adequate alignment of supply of and demand for care at the operational level where patients are booked in the time slots of the tactical master schedule. These planning levels may be more formally determined by the amount of randomness that is revealed in the planning process. At the operational level, the professional, the patient and the required treatment are matched. Randomness remains since, e.g. the treatment time might vary, the patient might not show up or arrive late, or the care-provisioner might be absent due to illness. At the tactical level, the schedule or capacity of the professional or type of professional is revealed, but the patient is not yet known. Thus, the number of patients that may be planned is known, but not which specific patients will be planned, which adds a second layer of randomness. At the strategic level, only the total capacity of the professionals is known, but not the number and type of the patients, adding a third layer of randomness to the planning problem.

2.2 *Planning Complexity*

A major part of the complexity of the decision-making process in healthcare planning lies in the type of appointments that must be planned. Usually, planning a single appointment, procedure or episode of inpatient care is less involved than planning several activities for one patient at once, especially when these are interrelated and of heterogeneous nature and need to be planned in a certain chronology. To this end, we introduce planning complexity as a third dimension in the framework and distinguish three types of complexity, single item planning, multidisciplinary planning and care pathway planning, which will be briefly described below based on the characteristics introduced in [16, 17].

2.2.1 *Single Activity Planning*

In single activity planning, appointments, procedures or episodes of inpatient care are planned subsequently, one by one, on a single resource. Characteristics which are important to consider are, a.o. [17] future demand from other patients for the same service period; the number and availability of resource types at the facility; and the horizon at which the scheduling decisions are made.

2.2.2 *Multidisciplinary Planning*

In multidisciplinary planning, coordinated packages of care for patients are planned. This can either be a single activity on multiple resources or multiple activities on a single or multiple resources [17]. Next to the characteristics important for single activity planning, additional characteristics to consider are, a.o. the number of activities to be scheduled in a certain time frame; requirements on the number of activities to be scheduled within a certain time entity of the time frame (e.g. a week); and the chronology and relationships among the activities to be scheduled.

2.2.3 *Care Pathway Planning*

Care pathway planning is in many ways similar to multidisciplinary planning. The main difference is that care pathways (sometimes also referred to as clinical pathways) are designed to exactly specify the care trajectory for an entire group of patients (e.g. patient types), 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 also the planning complexity [16]. Note, however, that the adherence to these pathways is usually low [12], which may result in an increase in (operational) planning and scheduling complexity. Next to the characteristics important for single and multidisciplinary planning, additional

characteristics to consider are, a.o. the magnitude of the patient group included in the care pathway and interference of care pathway planning with the planning process for other patients and/or patient groups.

2.3 A 3D Framework for Planning Decisions in Healthcare

We introduced three dimensions for planning decisions in healthcare: services, the hierarchical level and planning complexity. We consider five services (ambulatory, emergency, surgical, inpatient and home care), four hierarchical levels (strategic, tactical, operational offline and operational online) and three complexity planning levels (single activity, multidisciplinary and care pathway), resulting in $5 \times 4 \times 3 = 60$ subcategories that are graphically presented in Fig. 1.

3 Positioning of Overview Papers on Patient Planning and Scheduling Decisions in Healthcare in the 3D Framework

This section provides a starting point for further reading,¹ by identifying recent surveys and review papers on patient planning and scheduling and positioning these papers in our 3D framework in Fig. 1. Our aim is not to provide an in-depth description of these levels of complexity as these are covered in later chapters but to illustrate the levels that are extensively covered and those that are seldomly addressed in literature.

Using Google Scholar we applied the following search strategy and selected 15 papers:

- recent articles published since 2000;
- focus on patient planning and scheduling decisions, not on staff scheduling or medical planning (i.e. topics such as advanced care planning or discharge planning are excluded);
- should have either *survey* or *review* in the title;
- should have either *planning* or *scheduling* in the title; and
- one of the following words in title: *healthcare, health care, patient, appointment, surgery, surgical, operating, inpatient, outpatient, ambulatory, emergency, home care*.

Our inclusion criteria did not result in surveys or reviews on patient planning and scheduling available for the emergency care services including facilities such as emergency departments, ambulances and trauma centres, but not including emer-

¹See also the online reference database of OR/MS literature [10] provided by the Center for Healthcare Operations Improvement and Research.

Care pathway	[14]	Strategic	Tactical	[14]	[14]	[14]	[14]	[14]	[14]
		Operational offline	Operational online						
Multi-disciplinary planning	[13, 14] [15]			[14]	[14]	[14]	[14]	[14]	[4, 6, 7]
	[17]			[15]	[15]	[15]	[15]	[15]	[17]
Single activity planning	[1]			[2, 18, 19]	[17]	[17]	[17]	[17]	[4, 6, 7]
	[3, 8]			[8]					
[11]		Emergency care services	Emergency care services	Surgical care services	Surgical care services	Inpatient care services	Inpatient care services	Home care services	Home care services
		Ambulatory care services	Ambulatory care services	Ambulatory care services	Ambulatory care services	Ambulatory care services	Ambulatory care services	Ambulatory care services	Ambulatory care services

Fig. 1 The 3D framework with the 15 selected papers. The taxonomy presented in [11] falls into all categories

gency patients within the OR environment. This is clear for the operational planning level, since emergency patient care cannot be planned on individual (patient) level. On the tactical and strategic level, however, patient planning and scheduling should support the decision-making process. Further observe that literature on ambulatory care, surgical care and inpatient care seems connected, but literature on home care services seem not to have a relationship with the other services covered in the framework. Regarding the hierarchical planning levels, the included papers focus either on all levels or on the operational level. When considering planning complexity, papers covering care pathways are scarce. This might be due to the lack of a uniform definition of care pathways from a mathematical perspective.

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