Title

Models as instruments to optimize hospital processes: a systematic review

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Abstract

Increasing complexity of hospital organisations causes that hospital management is more and more in need for tools that support their decisions. The main problems they face in order to optimize hospital performance are capacity problems, process design problems and scheduling problems. This systematic review had the objective to search for literature concerning models for the design and control of processes concerning patient flows within departments in a hospital. Two complementary goals were to find relations between sort of problems and most appropriate model types and to find out how usable these models are for managerial decision making. Here fore, within three databases relevant literature has been selected based on inclusion and exclusion criteria. 68 articles have been selected, of which 31 containing computer simulation models, 10 descriptive models

and 27 analytical models. The review showed that descriptive models are only applied for process design problems and that analytical and computer simulation models are applied for all types of problems in approximately the same proportion. The relevant databases appeared to be limitedly comparable and the amount of suiting keywords or mesh headings insufficient, through which searching systematically in the wide field of health care management is relatively hard to accomplish. The review did not result in a preferred model type in a given situation, probably because this choice is usually based on available expertise. Only few models have been validated in practice, and it seems that most models are not used for their purpose; to support management in decision making.

Introduction

"Man is a tool using animal…. Without tools he is nothing, with tools he is all."

--Thomas Carlyle

Hospitals' identity as a health community slowly transposes to the identity of an enterprise. Hospitals get bigger, apply higher relative amounts of non-medical employees, get more critical customers and operate in a increasingly competitive climate. Average patient stay has been reduced considerably and the number of outpatient versus inpatient alters continuously, resulting in less intensive patient-care giver relationships. The traditional conflicting pressures of maximizing the quality of patient care versus ensuring organizational survival, have become especially acute due to recent economic pressures. (Williams *et al.* 2005) These developments have resulted in more complex and business-like organizations that have brought more challenges to deal with. The complexity of the system causes ambiguity in terms of how an individual's work should be performed and how the work of many individuals should be successfully coordinated into an integrated whole. (Spear 2005) This new situation for hospitals requires an increased professionalism of hospital management to be able to make the right decisions.

One of the most significant problems which management has to deal with is the use of hospital's limited resources in relation to increasing demand for both quantity and desired service level. The challenge is to manage the system consisting of arrivals, activities and resources. While facing this challenge, managers meet three main types of problems:

1. Capacity problems; what kind and what amount of resources to attract
2. Process design problems; which process steps to make use of and in what order
3. Scheduling problems; at what moment to allocate which resources to which patients

These problems become more and more complex, due to many uncertainties in the system, better represented as the four types of variability. First, patient arrival variability is caused by the unpredictable moment that patients enter with their demand for service. Second, variability of demand represents the variation in type and amount of care patients require. Third, routing variability is the variation in process steps and their order within patient flows. Fourth, process time variability is the fluctuation in duration of process steps. These types of variability are the main source of the problems managers face, concerning design and control of hospital processes.

To deal with the main problems concerning managing the systems in a hospital, traditional clinical research methods barely suffice. Randomized controlled trials and controlled experiments cannot be carried out adequately, due to too many dependent variables. Moreover, those methods are too risky and expensive, and consequently in general not suitable in these situations. Therefore there is an increasing need for tools to predict the consequences of different alternative scenario's. In complex situations decision makers can use managerial models that predict the results of a scenario. A model helps to understand the behavior of a system without actually changing the system.

There have been various studies about managerial models designed for hospitals' situation. Usually they describe or compare specific types of models, such as simulation models and Markov chain models. (Karnon 2003; Karnon & Brown 1998) Furthermore they usually describe modeling techniques, not models that have been practically applied in hospitals. Systematic reviews of the literature in this field are especially rare. Reviews generally deal with a specific range of models, such as computer simulation models. (Lehaney B 1995; Marshall *et al.* 2005; Fone *et al.* 2003) This study focuses on various kinds of decision supporting models and is thus not limited to a specific range of models. In addition, instead of focusing on the whole hospital, it only deals with processes within specific hospital departments. First of all, the complexity of the hospital organization and the amount of different kinds of processes make it extremely hard to generate a straight forwarded solution to the main challenge for the whole hospital. Designing a model at this level would be very abstract and result in information with insufficient value. Secondly, focusing on the whole hospital is very often not necessary. According to the theory of constraints, attacking 'bottleneck' processes or departments is the fastest and most effective way to streamline flows through an organization (Goldratt EM & Cox J 1992).

The primary objective of this study was to search for literature concerning models for the design and control of processes concerning patient flows within departments in a hospital. These models must be appropriate to get insight in and to consider different scenarios with the aim to optimize the performance of these departments. The secondary objective was to find if there was any relation between the type of problems and the model types used. The third objective was to find out how usable these models are for managerial decision making. Therefore this study also reflects on the applicability of the models results and the models extend of being generic.

Theoretical background

The first concern is to set down clear definitions. Apart from a formulation for a model, types of models and problems have to be defined to find out which models are used for which problems.

Problem types

Many classifications for problem types are possible. A classification has been chosen that fits best our primary objective, based on two theoretical frameworks. In Slack's framework (Slack *et al.* 2003) operations management problems are classified in the topics design, planning and control and improvement. According to our objective, all problems relevant to this review are related to improvement, but the improvement always concerns the process design or the planning and control in hospitals. Therefore the topic improvement does not occur in the classification in this review. According to the framework for hospital planning and control (Hans *et al.* 2007), planning and control has different appearances. The framework distinguishes four hierarchical levels; strategic, tactic, operational offline and operational online, which are successively described as 'capacity dimensioning', 'allocation', 'scheduling' and 'control'. In our classification the capacity problems correspond with 'capacity dimensioning', scheduling problems contain both 'allocation' and 'scheduling'. The relevant scheduling problems in this context do not contain the level 'control', since our concern is patient flows and not patients who are already present in the hospital. The managerial decisions relevant in this study occur 'before the action', not during the action (online). In literature scheduling problems often deal with rostering: assigning human resources to shifts. This kind of problems do not belong to our definition of scheduling problems, since they also do not directly deal with patient flows. In summary the employed classification for problem types is:

- Capacity problems;
- Process design problems;
- Scheduling problems.

What is a model?

A model is a wide notion with many possible and employed explanations. A wide definition of a model is an artificially created system that represents reality. A system is a compilation of elements which are related, so that no elements are isolated from the remaining (De Leeuw 2000). Law (Law & Kelton 2000) defines a model as ‘a set of assumptions about how a system works, to try to gain some understanding of how the system behaves’. The most significant aspect of this formulation is the last part. The models we seek for give insight in consequences of possible managerial decisions (scenarios) to set up or change a system and therefore insight in its behavior. Leeuw (De Leeuw 2000) adds the notion that the way a model is built, depends on the aim of use, which means that many possible models can be of use for a given system. According to our objective the definition employed in this review is therefore: *a representation of a real system that gives insight in the system’s behavior, with interfaces with reality corresponding with the aim of use.*

The traditional model types are the physical model and the descriptive model. Descriptive models give insight in a system’s behavior by describing relationships between aspects of the system. Physical models imitate real shapes and sometimes movements of a system. Applications of physical models still occur in civil technique and building development, however not as a tool for hospital managers and therefore these are irrelevant for this study. Later modeling development brought us mathematical models. They represent a system in terms of logical and quantitative relationships that are then manipulated and changed to see how the system reacts. Mathematical models can be divided in analytical models, which are able to gain exact information on questions of interest, and simulation models, where true characteristics of a system are estimated. The pre-assumption is that different model types perform best depending on the type of problem. In summary:

1. Descriptive models; models that visually or textually represent a solution. A descriptive model is flexible and often easy to understand and use, however they lack a quantitative and accurate insight in system behavior.
2. Analytical models; models that can calculate output measures of interest for fictive scenario's. The advantage is that they are exact and quantitative, but usually difficult to interpret it's results. In complex processes they often ignore too many factors to be able to compare its quantitative results with reality.
3. Computer simulation models; models that use computer software to simulate variations of the real process accelerated, and afterwards show output measures. Computer simulation models are the most accurate model types, because they calculate over time and often take into account variability. The disadvantages are the costs and the development time needed.

Methods

Search Strategy

We selected three different databases. The medical database Medline containing articles from 1950 through 2006, the medical database Embase containing articles from 1980 through 2006 and the management science database Business Source Elite (BSE) containing articles from 1985 through 2006. For our search trough the databases we formulated inclusion and exclusion criteria (listed in Table 1).

Inclusion Criteria	Exclusion criteria
Articles containing a model that deals with the design and/or control of a process	Articles using models that have the goal to optimize more than one department at a time
Articles with models concerning patient flows that can be applied on departments within a hospital. Articles may concentrate on optimizing the performance of either a whole department or a function or process within a department	Articles not published in peer-reviewed journals or published as a full paper in conference proceedings
Articles using simulation based, descriptive or analytical models. We both look for models that tell us how to come to the optimal situa-	Articles concerning models that support medical considerations

tion, and models that directly suggest a specific design	
Articles containing models those directly aim on improvement of the performance of the process. Performance is defined as the product quality, customer service, flexibility, timeliness, reliability, safety, and quality of work	Articles with models primary concerning implementation of organizational change
	Articles suggesting models that primary forecast or predict demand or length of stay
	Articles containing models that primary demonstrate relationships
	Articles concerning software and/or hardware and IT with no direct effect on patient flows
	Articles suggesting models that describe an organizational structure

Table 1 - Inclusion and Exclusion criteria

We searched through the Medical Subject Headings database to find useful MeSH heading per inclusion criteria. Several MeSH headings were found per criteria. Using these headings, a number of titles and abstracts were retrieved for each heading and evaluated for relevance. If a relevant abstract was found, the other MeSH headings of this abstract were also evaluated for relevance. All the founded MeSH headings were entered in the keyword (subject headings) database of Embase to find the corresponding keywords (subject headings). Not all the MeSH headings had corresponding subject headings so the results of the subject headings were also evaluated for relevance. From the relevant abstracts, we derived free-text words for each criterion to increase the specificity of our search strategy.

In Business Source Elite (BSE) the MeSH and Subject headings were used to find corresponding BSE keywords in the same way as finding the corresponding subject headings. BSE is not a medical database, which resulted in slightly different keywords and free text words. The keywords and free-text words are listed in the appendix.

To suffice all the criteria the articles needed to contain at least one keyword or free-text word per criteria. After performing our search with the selected keywords and free-text words, articles were then selected based on the title and abstract. Two reviewers independently evaluated titles and abstracts to select articles for the review. The two reviewers determined together through discussion of which article the full text was useful for the review. This was done based on the inclusion and exclusion criteria. In case of disagreement a third reviewer was consulted. Full publications of all selected abstracts were obtained (in electronic or printed form) for the two reviewers to evaluate the full text. The results of the evaluations were compared and the differences in opinions were solved through discussion. When the final list of the included articles was finished, the references of these articles were evaluated for relevance. Seemingly relevant referred papers were obtained and evaluated in the same way as the other papers.

The authors developed a classification table in order to structure the literature. The two reviewers independently collected data to reach the review objectives, using the classification table (Table 2). To make sure that there are no differences in the definition of terms between the reviewers, the definitions were cleared beforehand (Table 2). The results of the two reviewers were compared and the differences in opinions were solved through discussion.

Item	Defenition	Categories
Type of model	*What type of model is described in the article*	* Computer simulation * Descriptive * Analytical
Type of problem	*What type of problem is described in the article*	* Capacity problem * Process design problem * Scheduling problem
Sort of department applicable on	*On what sort of department is the model applicable*	* Imaging diagnostics * Inpatient * Outpatient * Operation room * Laboratory * Intensive Care * Radio therapy * Emergency room
Objective of study	*What is the objective of the study (not of the model)*	* Design of a model * Comparison of models * Use of a model * Critize/propose a model

Outcome measure 1 and 2	*Outcome measures are the measures where the results of the model are critized on. Per article one or two outcome measures are defined.*	* # of appointments * # patients * Access denial probability * Access times * Costs * Length of stay * Needed capacity * Overtime * Patient's experiences * Quality of care * Random performance indica-tors * Throughput time * Utilization * Waiting times * Workload
Validated in practice	*An article is validated in practice when the results of the model are applied in the hospital (not when only the model is validated)*	* yes * no
Generic	*An article is generic when the model is usable in another hospi-tal and/or department*	* yes * no

Table 2 - Classification table

Results

Overview

The flow chart of the review is shown in Figure 1. With the search for keywords we found a total of 27 relevant MeSH headings in Medline, 21 relevant subject headings in Embase and 11 relevant keywords in Business Source Elite. The keywords and free text words are sorted by criteria in the appendix. Using the search strategy that the article must contain at least one of the keywords or free text words per criteria, resulted in a total of 609 articles. All the abstracts of these articles were read by two reviewers, who selected 128 articles for further evalution. Of these articles, one was in German, one in Tsjech and one in Swedish. 10 articles were excluded from the review, because the full texts could not be obtained. The 118 articles were evaluated by the reviewers, who selected 64 articles that met the inclusion and exclusion criteria.

Most articles were excluded because they modeled more than one department or were not related to patient flows. The references of the selected articles were evaluated to seek more relevant articles. This resulted in four extra articles relevant for the review.

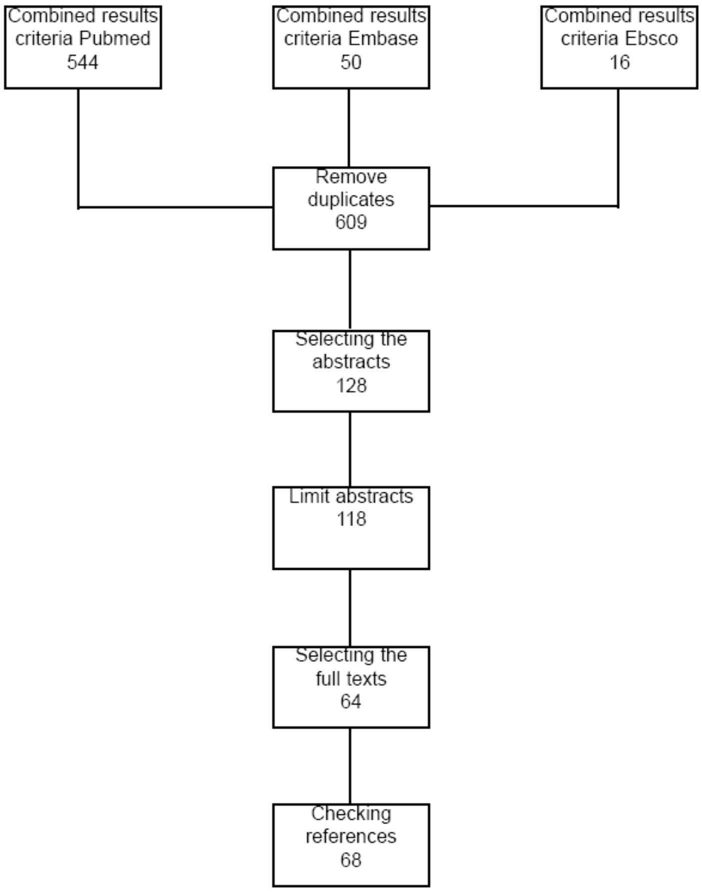

Figure 1 - Flow chart of the systematic review

Data collection

From the selected studies we collected the data summarized in the table 2.

Types of models			Type of problem			Sort of departments			Objective of study		
	#	%		#	%		#	%		#	%
Computer simulation	31	46	Capacity problem	10	15	Imaging diagnostics	2	2,9	Design of a model	51	75
Descriptive	10	15	Proces design	35	51	Inpatient	13	19	Comparison of models	8	12
Analytical	27	40	Scheduling	23	34	Outpatient	14	21	Use of a model	4	5,9
						Operating room	16	24	Critize/propose a model	5	7,4
						Laboratory	2	2,9			
						Intensive care	6	8,8			
						Radio therapy	1	1,5			

Emergency room	14	21

Outcome measures			Validated in practice			Generic		
	#	%		#	%		#	%
Utilization	25	22	Yes	17	25	Yes	33	49
Waiting times	17	15	No	51	75	No	35	51
Needed capacity	15	13						
Costs	14	12						
Throughput time	12	11						
# patients	8	7						
Other	23	20						

Table 3 - Collected data

As illustrated in Table 3 only 15% of the studies contain descriptive models. Analytical (40%) and computer simulation (46%) models are evidently used more. Half of the studies (51%) examine a process design problem, while scheduling problems and capacity problems successively represent 34% and 15%. The models are for the greater part applicable on the operating room (24%), emergency room (21%) and outpatient (21%) departments.

The greater part of the studies (75%) has the objective to design a model. Only 25% of

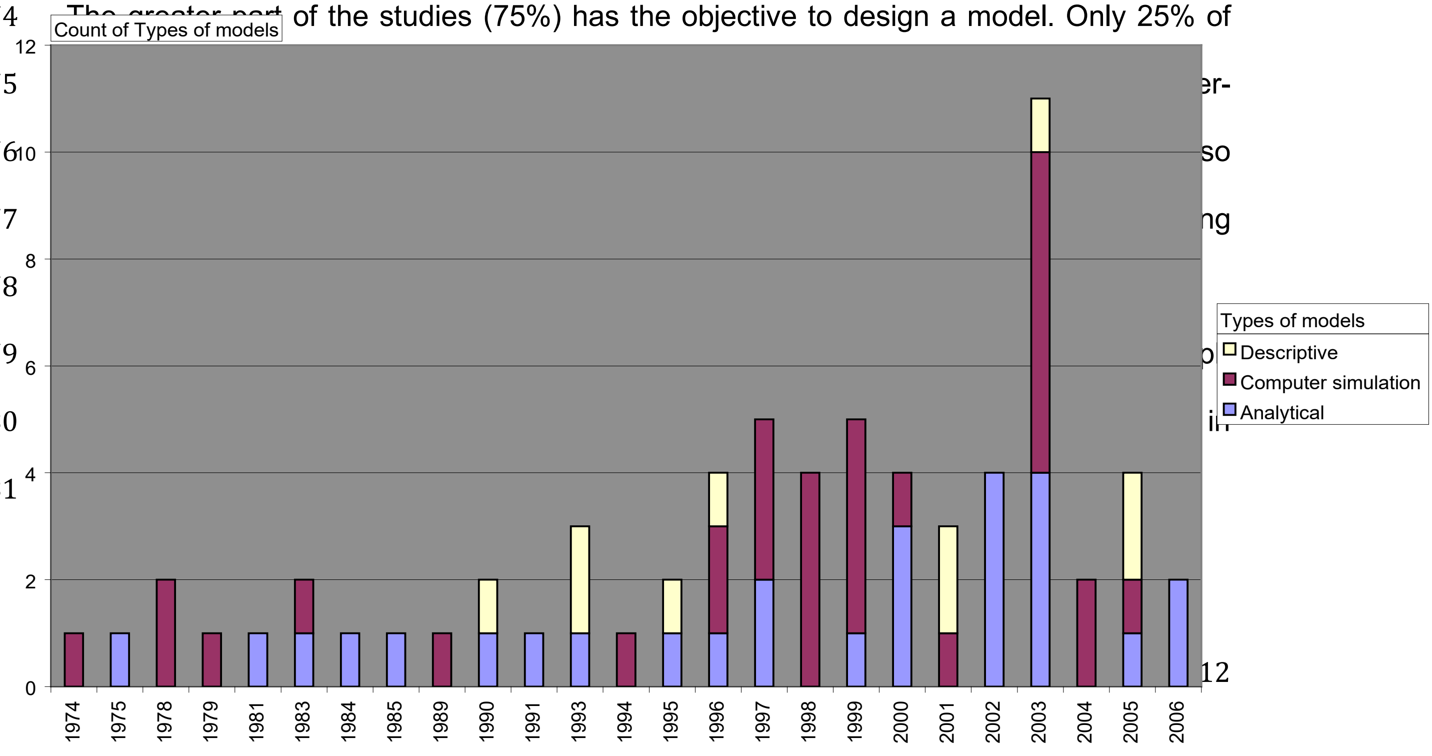

Figure 2 - Number of articles per type of model per year

Type of problem and model

The relation between the type of problem and model is illustrated in Figure 3. Descriptive models are only used for process design problems. The figure states that capacity and scheduling problems are comparable with each other. The only difference is that capacity problems are slightly evaluated more with analytical models and scheduling problems more with computer simulation models. Process design problems are evaluated with all types of models, but most often with simulation models.

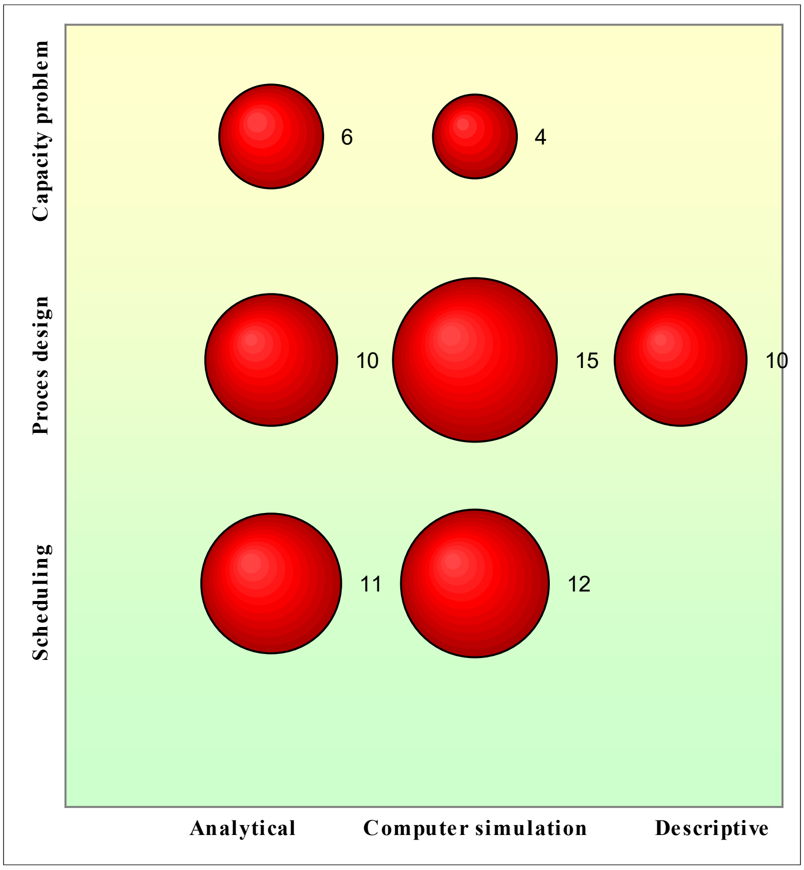

Figure 3 - Relation between type of problem and type of model

Type of problems related to the other categories

In Table 4 the relations between the problem type and the other categories is shown.

		Problem type						
		Capacity problem		Proces design		Scheduling		
		#	%	#	%	#	%	total
Department	Emergency room	1	7%	11	79%	2	14%	14
	Imaging diagnostics		0%	1	50%	1	50%	2
	Inpatient	3	23%	8	62%	2	15%	13
	Intensive care	3	50%	2	33%	1	17%	6
	Laboratory		0%	2	100%		0%	2
	Operation room	3	19%	3	19%	10	63%	16
	Outpatient		0%	7	50%	7	50%	14
	Radio therapy		0%	1	100%		0%	1
Generic	No	4	11%	17	49%	14	40%	35
	Yes	6	18%	18	55%	9	27%	33
Validated	No	10	20%	21	41%	20	39%	51
	Yes		0%	14	82%	3	18%	17
Outcome measure	Utilization	2	8%	10	40%	13	52%	25
	Waiting times	0	0%	9	53%	8	47%	17
	Needed capacity	8	53%	5	33%	2	13%	15
	Costs	2	14%	6	43%	6	43%	14
	Throughput time	0	0%	9	75%	3	25%	12
	# patients	1	13%	6	75%	1	13%	8
	Other	3	13%	15	63%	6	25%	24

Table 4 - Relation between problem type and other categories

In the operating room mostly scheduling problems are examined (63%). Process design problems occur in every department, but mostly in the emergency room (79%) and inpatient (62%) departments.

Type of models related to the other categories

Table 5 reveals the relations between the problem type and the other categories.

		Model type						
		Analytical		Computer Simulation		Descriptive		
		#	%	#	%	#	%	total
Department	Emergency room	4	29%	6	43%	4	29%	14
	Imaging diagnostics	1	50%		0%	1	50%	2
	Inpatient	8	62%	3	23%	2	15%	13
	Intensive care	1	17%	4	67%	1	17%	6
	Laboratory		0%	1	50%	1	50%	2
	Operation room	8	50%	8	50%		0%	16
	Outpatient	4	29%	9	64%	1	7%	14
	Radio therapy	1	100%					1
Generic	No	4	11%	31	89%		0%	35
	Yes	23	70%		0%	10	30%	33
Validated	No	22	43%	27	53%	2	4%	51
	Yes	5	29%	4	24%	8	47%	17
Outcome measure	Utilization	12	48%	12	48%	1	4%	25
	Waiting times	7	41%	10	59%	0	0%	17
	Needed capacity	6	40%	8	53%	1	7%	15
	Costs	7	50%	4	29%	3	21%	14
	Throughput time	2	17%	9	75%	1	8%	12
	# patients	5	63%	3	38%	0	0%	8
	Other	9	38%	5	21%	10	42%	24

Table 5 - Relation between model type and other categories

What stands out in this table is that descriptive models are always generic, on the other hand computer simulation models are never generic. Analytical models are most of the times generic. Also remarkable in Table 5 is that analytical and computer simulation models are barely validated in practice. On the other hand most of the descriptive models are validated in practice.

Discussion

Few systematic reviews have been applied in the specialism of health care management (Elkhuizen *et al.* 2006). This is remarkable, since the systematic review is a widely used and highly accepted research technique in health care. In systematic reviews, the aim is usually to collect all relevant research about one specific topic in order to assess ‘the real truth’ among the often many contradictions. When the topic concerns a causal relation that is the basis for an optimal treatment or diagnosis method, finding a ‘real truth’ is often possible. In management research this is more complicated, due to the many elements and relations within the managed system and the large differences between specific situations. Besides, this study made clear that the search itself is also more complicated in the topic of health care management. Despite the well outlined and clearly defined inclusion and exclusion criteria, the subject appeared to be widespread. Literature was found in journals about general management, operational research, operations management, health management and various hospital departments such as anesthesia, radiology, intensive care, surgery and emergency care. This shows the significance to consult various databases when searching for health care management topics. Unfortunately the comparability of the databases, especially between management databases and medical databases, is insufficient. Moreover the supply of mesh headings or keywords in management databases badly matches the aim of systematically searching for health care management literature and the management mesh headings or keywords in health care databases are inadequately developed. As a result, searching for articles about optimization of hospital processes is a time consuming activity and contains the risk that despite of a systematic procedure of reviewing, not all relevant literature may be found.

Our goal was to search for descriptive, analytical and computer simulation models and to find a relation between type of problems and model types, being capacity problems, process design problems and scheduling problems. Both descriptive models as analytic models and computer simulation models are used often in order to attack the problems. In advance, an increase in the amount of used models and a shifting towards more advanced models, such as computer simulation models, was expected, due to the increasing management professionalism in hospitals. The review showed indeed an increase in the amount of models, but did not bring out a development over time from descriptive models towards more and more computer simulation models. It is possible that the relative use of simulation models did actually increase in comparison with less advanced models, because of fewer reporting since simulation models may often not be seen as scientific relevant. The results of this review showed some characteristics of the particular types of models. Firstly, descriptive models are often generic and mostly validated in practice, are used in different kinds of hospital departments, and use a range of outcome measures. Secondly, analytical models are mostly generic, but usually not validated in practice. Analytical models are especially often used in inpatient and OR departments. Main outcome measures are utilization, waiting times and needed capacity. Thirdly, computer simulation models are never generic and mostly not validated in practice. They were mainly used in outpatient, OR and ED departments. Here, the same often used outcome measures are used as for analytical models, replenished by throughput time.

It is useful for managers to know which model type to choose in a given situation. All relevant models within this review are aimed to attack a managerial problem that can be classified in one of the three types of problems; capacity problems, process design problems and scheduling problems. The most obvious relation between model type and problem type is that descriptive models were only found for process design problems. Capacity and scheduling problems are attacked by both analytical and computer simulation models in about the same proportion. Process design problems, the most encountered problem, are somewhat more attacked by computer simulation models than by the other two model types. Furthermore no significant relations could be distinguished. No article mentioned about the required expertise, the time needed and the costs of the model. Obviously this information is relevant concerning the choice of a model. In fact the reasoning for the chosen model type was absent in all relevant studies. It presumes that the choice for a specific type of model is for the bigger part based on the available expertise and resources.

For this review a managerial model is defined as a representation of a real system that gives insight in the system's behavior, with interfaces with reality corresponding with the aim of use. The aim of use is to help the manager confronted with a problem, to solve the problem by giving insight in the consequences of different scenario's. Based on this insight, management can decide to change aspects of the organization (or not) and in what matter. It is striking that the absolute majority of the papers didn't mention about the managers' decision based on the models outcomes. In other words, it was not possible to find prove that the models are used in the way they are meant for. This leads to the assumption that often the mean becomes the objective, that is building the model is more important than using it. A probable explanation is that models written about in peer-reviewed literature are mainly built by researchers meant for scientific reasons in stead of application in practice. This could be a bias in our review, because we only searched in scientific databases. We are perfectly aware of the fact that a huge amount of effective models are used by managers, which is not published about. We suggest to researchers to pay more attention for basing the similarities on the aim of a model; a simpler model is often possible and more effective.

Conclusion

Models for the design and control of processes concerning patient flows within departments in a hospital are frequently applied for managerial problems in hospitals. Our review resulted in a promising amount of papers, but few reported the consequences of the implementation of the model's results, especially not analytical models and computer simulation models. This makes it hard or impossible to evaluate the usability of the models. Furthermore no clear relation between a problem type or situation and the most effective model type could be found. Which model suits best depends on many parallel factors. In general descriptive models suit best when it must be generic and qualitative and computer simulation models suit best when situations are complex with high extends of variability and results must be specific and quantitative.

We propose introducing more specific mesh headings and keywords to improve the tractability of health care management studies. We succeeded to find interesting relations, but cannot conclude with a best model when confronted with a specific type of problem. It depends on too many elements besides the problem type. Up to now research overviews within the field of health care management have almost exclusively been performed by random searches. We claim that in the context of health care management a systematic review is an effective technique to get a reliable overview of research on a subject.

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Appendix 1: Keywords

Criteria	Pubmed mesh headings	Embase subject headings	Business Source Elite keywords
1.Design/control model	- Personnel Staffing and Scheduling - Decision Support Techniques - Health care rationing - Hospital planning - Health resources - Workload - Systems analysis - Planning techniques - Forecasting - Appointments and schedules	- Hospital Planning - Patient Scheduling - Health Care Financing - exp resource management - Process design - Process control	- Scheduling - Planning - Medical care – Cost shifting - Decision support systems
2.Supporting departement	- Hospital Departments - Hospital Units	- Hospital Department	- Hospitals
3.Kind of model	- Models, Statistical - Models, organizational - Models, Theoretical - Systems Theory - Computer Simulation	- Experimental Model - Theoretical Model - Computer Model - Statistical Model - Stochastic Model - Process Model - Computer Simulation	- Models & modelmaking - Mathematical models
4.Performance improvement	- Efficiency, Organizational - Time management - Length of Stay - Bed Occupancy - Hospitals/utilization - Patient Admission - Organizational innovation - Time factors - Quality of health care - Waiting lists	- Time Management - Productivity - Health Care Quality - Job Performance - Hospital Utilization - Hospital Admission - “Length of Stay”	- Time management - Mathematical optimization - Waiting period - Health facilities- Utilization

Appendix 2: Free text words

Free text words: Embase and Pubmed
Criteria 1: patient process, process of the patient flow, patient flow process, design of the process, process design, design of the patient process, process management, management of the process, management of the patient process, manage the process, manage the patient process, managing the process, managing the patient process, process control, control of the process, control of the patient process, operations management, organization of the process, organization of the patient process, organizing the process, organizing the patient process, organization of the process, organization of the patient process, organizing the process, organizing the patient process, organization of the process, organization of the patient process, organizational design, organisation of the process, organisation of the patient process, organising the process, organising the patient process, organisation of the process, organisation of the patient process, organising the process, organising the patient process, organisation of the process, organisation of the patient process, organisational design

Criteria 2: department, hospital division

Criteria 3: model, framework

Criteria 4: optimization of resources, resource optimization, resource utilization, utilization of resources, process optimization, optimization of the process, optimizing the process, process improvement, improvement of the process, improving the process, improving the patient process, optimizing the patient process, improving performance, performance improvement, capacity utilization, utilization of capacity, optimisation of resources, resource optimisation, process optimisation, optimisation of the process, optimising the process, optimising the patient process, resource utilisation, utilisation of resources, capacity utilisation, utilisation of capacity

Free text words Business Source Elite
Criteria 1: process, design, control, operations management

Criteria 2:
Hospital

Criteria 3: model, method, framework, tool

Criteria 4: optimization of resources, resource optimization, resource utilization, utilization of resources, process optimization, optimization of the process, optimizing the process, process improvement, improvement of the process, improving the process, improving the patient process, patient flow, improving performance, performance improvement, quality of care, care quality, quality of health care, health care quality