Systematic Review

Models as instruments to optimize hospital processes

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Preface

This report is the final assignment for my bachelor Industrial Engineering and Management at the University of Twente. The Amsterdam Medical Centre (AMC) initiated the assignment. After two years of working on this assignment I am content with the results, which are presented in this report.

I would like to thank Jasper van Sambeek for the good cooperation and interesting discussions during the performance of our systematic review. I would also like to thank Professor Krabbendam for his support and advice. I would also like to thank Piet Bakker of the AMC for his critiques on the review and paper.

Introduction

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 an increasingly competitive climate. 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). This new situation for hospitals requires an increased professionalism of hospital management to be able to make the right decisions. To support the hospital management in making the right decisions, managerial models can be used. A model can help to understand the behavior of a system without actually changing the system.

The primary objective of this research 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 described in the article 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.

To reach the objective a systematic review was performed. The systematic review is a method for finding and criticize "all" the published literature on a specific topic. It is impossible to explore all published literature, because not all the literature is stored properly. However, a systematic review is the method that comes closest to this objective.

When conducting the systematic review it became clear that not much information was found on systematic reviews in the management science. That is why the first part of the report consists of a manual with guidelines how to perform a proper systematic review in the management science. In this part there is also a briefly reflection on the usability of the systematic review in the management science.

The second part of the report consists of the protocol of the systematic review with the objectives, search and selection strategies. In the last part the answers to the objective will be presented in the form of an article.

PART I: A Systematic Review

1.1 What is a systematic review

A systematic review is a review that strives to comprehensively identify, track down, and appraise all the literature on a specific topic[1].

In 1979 Archie Cochrane's (British epidemiologist) published the seminal 'Effectiveness and efficiency', which urged health care practitioners to make use of systematic reviews to increase the reliability of the health care system. In the same year the first overview was published on the topic of perinatal trails. To simplify the search for published studies and to promote more systematic reviews, the need for databases containing registered studies increased. In 1982 the World Health Organisation funded a microcomputer for the storage of studies in a database. In the last ten years the databases evolved enormously and made it easier to conduct a systematic review. In 1993 the Cochrane Collaboration, named after Archi Cochrane, was founded. The Cochrane Collaboration is an international not-for-profit and independent organization, dedicated to make up-to-date, accurate information about the effects of healthcare readily available worldwide. It produces and disseminates systematic reviews of healthcare interventions and promotes the search for evidence in the form of clinical trials and other studies of interventions[2]. Nowadays systematic reviews are a highly accepted research technique in health care.

Few systematic reviews have been applied in the specialism of health care management[3]. This is remarkable, since it is so widely accepted in the 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 science this is more complicated, due to the many elements and relations within the managed system and the large differences between specific situations. Based on these differences, the method for performing a systematic review in the health care cannot be completely used when performing a systematic review in the management science. In the following subsections the method for performing a systematic review in the management science based on the handbook developed by the Cochrane Collaboration[4].

1.2 Why a systematic review

There are several reasons to perform a systematic review. These are stated beneath.

- Annually more articles are published then one person can read. In the electronic library of the University of Twente more then 3000 magazines are founded when looking for management magazines. A systematic review can help to select the right

[1] Petticrew, 2003
[2] The evolution of the Cochrane Library, Star and Chalmers, 2003
[3] Elkhuizen et al, 2003
[4] For the guidelines of a systematic review in the health care sector see http://www.cochrane-net.org/openlearning/

information from this huge amount of information in an appropriate way. This information can help by rational decision-making.
- Systematic reviews can prevent researchers to explore a topic that has already been explored, which will save a lot of time and money.
- Systematic reviews can help explain inconsistency and conflicts in different researches, provided that the researches are comparable.
- Systematic reviews are mostly performed by more then one person. This will increase the accuracy and minimize the bias.
- The explicit methods used in a systematic review allow a valuation of what already has been done.

1.3 How to perform a systematic review

As to be expected from the name, the systematic review has to be performed systematically. According to the Cochrane Collaboration handbook a systematic reviewer has to perform the following six steps[5].

- Define the research objective
- Look for all studies addressing the question
- Sift the studies to select relevant ones
- Assess the quality of the studies
- Collect the information to reach the research objective
- Interpret results

In these steps there are several decisions a reviewer needs to make which can cause a consistent deviation from the truth, because for one reason the reviewer can have prejudices. For example the decision which criteria will be used for selecting literature. It is important to establish the methods and strategies that will be used during the process beforehand to make sure that during the review this process is preserved, as in any scientific research. This should be done as extensive and well defined as possible and documented in a protocol. This will prevent that changes in the methods and strategies during the review will occur. If during the review the reviewers run into problems concerning the protocol, the protocol can be adjusted but it needs to be documented and explained thoroughly.

In the next paragraphs a profound explanation of the six steps of the review will be given. These steps will concentrate on systematic reviews in the management science.

1.3.1 Define the research objective

Defining the research objective is the most important step of the review. It will be a guide for collecting and selecting studies in the next step. It should therefore be done extensively and discussed with several others.

Verschuren and Doorewaard made four requirements, which can be used to define a profound objective[6]. These four requirements are:

- The objective needs to be useful

[5] For the guidelines of a systematic review in the health care sector see http://www.cochrane-net.org/openlearning/

[6] Het ontwerpen van een onderzoek, Verschuren en Doorewaard, 1995

- The objective needs to be performable in the available amount of time.
- The objective needs to be formulated unambiguous.
- The objective needs to indicate which knowledge the research will generate.

The result of this step is a clear defined research objective.

1.3.2 Look for all studies addressing the question

For the systematic review a thoroughly search through information sources is needed to find relevant studies. For making a thoroughly search it is necessary to conduct the following steps.

1) Define the criteria for selecting the studies
2) Select the information sources which will be used
3) Develop a good and sensitive search strategy for searching through the different information sources
4) Search through the information sources according to the search strategy

Define the criteria
The criteria defined in this step operationalize the review objective and are used to decide which studies should be included or exluded from the review. These criteria can also be used to define the keywords for the search in the selected databases. In this step inclusion and exclusion criteria can be formulated. Inclusion criteria are the criteria which include a study and exclusion criteria exclude a study. It is not necessary to formulate exclusion criteria, but these will be useful in excluding the studies in a following step.

Select the information sources which will be used
Selecting the information sources is an important step because you do not want to miss a relevant study. This is very hard to achieve and might not even be possible in most reviews, because many studies are never published or not documented properly. At some point, the effort required to find more relevant articles becomes too high. Unfortunatly is that point hard to determine in advance. Most researchers look as far and as wide as possible, while taking into account the biases that can occur when finding studies.

When selecting the information sources for the review the following issues need to be considered:
- To make sure that the search is sensitive, it is necessary to search in more than one place, because no single database, journal or book will contain all the relevant studies.
- It can happen that a study is in a foreign language. This should not be a reason to exclude it from the review.
- The information sources should come from more then one country, to minimize bias.

It is recommended to consult a librarian to help find the right information sources. A librarian can give more information on which sources will be useful for the review.

Develop a search strategy
In the recent years the use of electronic databases is enormously increased. This has simplified the performance of a systematic review, because the studies in a database are stored systematically. With the use of keywords, relevant articles can be easily found.
Some databases work with standard keywords which are listed in the database and given to the studies in the database by the managers of the database. To find standard keywords which are usefull for the review the inclusion and exclusion criteria can be used, because they determine which study will be in the systematic review. After finding seemingly usefull standard keywords it it necesarry to test these keywords by evalutating if the search with a certain standard keyword results in relevant studies for the review. If a relevant study is found the standard keyword can be used for the review, if not it should be discarded. The other standard keywords of the founded study should also be evaluated for relevance.
In the search for the revelant studies also free text words can be used. These words are formulated by the reviewer and not standard for the database. The standard keywords are determined by a person and as said before, a person can make mistakes and for example overlook a keyword. To make sure that this will not influence the review, free text words are used. When searching through the database the search machine will look for these words in the whole text of the studies.

If the information sources and search strategy are determined, the thoroughly search through these sources starts. This results in a number of studies that could be relevant for the review and a list of inclusion and exclusion criteria.

1.3.3 Sift the studies and select the relevant ones

In the preface step the result could easily be thousands of relevant studies. It is impossible and not necessary to read all the studies completely. They need to be sifted. This is done by reading the abstracts[7] of the possibly relevant studies and comparing them with the inclusion and exclusion criteria. In this stage a mistake is easily made, because when looking at a lot of studies, it is easy to miss some information and mistakenly include or exclude a study. Also the reader will have certain prejudices which will also influence the decision to include a study. To minimize these mistakes and biases it is recommended to let more then one person read all the abstracts, which is also essential in all the following steps. After the individual evaluations of the studies by the reviewers, the results will be compared. When differences occur these need to be solved in a discussion between the readers. If it can not be solved in a discussion, another objective person could help to resolve the differences.
After the first sifting it is necessary to do another sifting by reading the full texts of the selected studies. Also in this stage it is recommended to do the reading with more than one person to minimize mistakes and biases.

After the selection, the references of the studies should be checked for more relevant studies for the review.

The result of this step is a list of studies that will be included in the review.

[7] An abstract is a stand-alone statement that briefly conveys the essential information of a paper, article, document or book; presents the objective, methods, results, and conclusions of a research project; has a brief, non-repetitive style (John December 1991). Most of the documented studies contain an abstract.

1.3.4 Assess the quality of the studies

The studies in the list of the previous step are selected based on their relevance for the review. The next step is to determine the quality of these studies. When studies with lower quality will be excluded from the review, the risk of error and bias in the review will be reduced.
Quality is a subjective conception, which makes it hard to establish standard quality aspects. It is useful to make a list of all the factors that can influence the quality of a study. From this list the factors relevant and important for the review are used to assess the quality. The next step is to collect information of these factors in the included studies.
In this step the issues of minimising mistakes and biases are the same as when we considered these in the step of selecting the studies. So also in this step it is recommended to let more than one person assess the quality of the different studies.

The result of this step is the quality of all the studies included in the review.

1.3.5 Collect the information to reach the objective review

In this step the information to reach the research objective is collected. Before the start of collecting the information, it needs to be exactly clear what information needs to be collected from the studies. What information is needed will follow out the formulated research objective. When this is determined the search in every study can start.

The result of this step is the needed information from all the studies.

1.3.6 Interpret results

In the last step the information gathered in the previous step will be analysed, commented and when possible combined. In this step the reviewer must be aware not to compare or combine results from not comparable studies. A method to avoid this is to first sort the studies in categories that can be compared and combined.

The result of this step is the analysis of the selected studies.

1.4 Evaluation of the use of systematic reviews in management science

Although the systematic review has advantages, it also has some disadvantages. In this chapter these disadvantages are being discussed and the usability of systematic reviews in management science is shortly evaluated. For this evaluation the reliability and quality of the results and the feasibility are also evaluated.

Reliability and quality of the results
When discussing the accuracy of the systematic review the following question needs to be adressed; would two reviewers with different backgrounds and beliefs come to the same conclusions when performing a systematic review with the same research objective?
As been said before reviewers can have prejudices that can bias the results of the review.
In the phase were the keywords are chosen a difference between two reviewers will have a great impact on the results of the review. When two different reviewers will select different keywords, other articles can be the result of the search and other conclusions can be made.

Although the selection of different keywords might seam to happen very easily it is mimized when the the reviewers follow the strict guidelines of a systematic review. The two most important guidelines that have a considerably effect on minimizing the differences are the fact that a systematic review needs to be conducted by two persons and the fact that the selected standard keywords carefully need to be evaluated for relevance.
When the reviewers use well structured databases with standard keywords the risk of selecting different keywords is also minimized.

As said above the use of properly structured databases is very important in perfroming a good systematic review. Among other things the quality of the databases depends on the number of studies stored in it and the manner in which they are stored. Are standard keywords used and how are the standard keywords determined per article?
The two databases that are mostly used in health care are Pubmed and Embase. Together these databases cover almost all the relevant articles on health care. The articles in these databases are stored systematically with the use of standard keywords, which simplifies the search for relevant articles. In management science no such database exists. The largest abstract and citation database (Scopus) does not make use of standard keywords. This makes it harder for the reviewer to search systematically through such a database. It contains also the risk that despite of a systematic procedure of reviewing, not all relevant literature may be found.
The determination of the standard keywords is done by humans who can make mistakes. These mistakes can lead to missing relevant articles for the review. As said in chapter 1.3.2. this can be resolved by using free text words, but this will lead to more (not relevant) articles for the review and so an increase in the time to review all the articles. So the better the standard keywords are defined the less free text words are necessary which will lead to less not relevant articles.

Feasibility
The major drawback of a systematic review is the time it takes to perform one. When performing a systematic review you need a lot of time to systematically search for relevant articles. This drawback is even more visible in a systematic review in the management science due to the fact that there are no good structured databases as described above.
Before starting a systematic review it is recommended to first define how much time and effort the reviewers are willing to invest in the research. Then try to find out if it is possible to conduct a systematic review in this time period. Although it is not easy to investigate this, a quick search through the (standard keywords) databases can give a good indication. Are there relevant standard keywords for the proposed research objective? If there are it will save time because the search through the databases is easier. It can also give an indication of the amount of articles that are published on the subject of the systematic review. The more articles found, the more time it will take to review them all and the more complicated it becomes to compare the articles with each other.

Usability
The usability of a systematic review in management science depends highly on the research objective. Which databases fits the research objective and are these databases structured enough? As said above the databases in the management science may lack this structure and make it harder to conduct an accurate systematic review in a reasonable time period. The broadness of the research objective plays also an important role. When the research objective

is too broad the time needed to conduct the systematic review may overcome the results of the review. Making the management databases more structured can increase the usability of the systematic review in management science. The searches will be easier and so time can saved.

PART II: Protocol for systematic review

2.1 Introduction

Decision makers in hospitals are more and more in need of instruments that can help them to control their costs and at the same time keep providing good and on time health care. We are particularly interested in the way hospitals design and control their processes, because industry taught us that great profits could be made here (Hopp & Spearman). Of course hospitals are no industrial enterprises, but we believe many parallels can be found between many processes.
Hospitals are relatively complex, due to many stakeholders, many integrated product lines and the nature of the main product: creating better quality of life. Because of this complexity, it will be very difficult – if not impossible – to find one instrument that restrains the design and control of a whole hospital. Therefore we will focus on a single department to optimize.

2.2 Objective of the review

To find and criticize literature about 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 one scenario or to consider different scenarios with the aim to optimize the performance of these departments.

2.3 Review method

We will use the following steps to complete the systematic review, which will be explained in the later paragraphs:

1. Select the databases we will use;
2. Formulate inclusion and exclusion criteria;
3. Define the search strategy;
4. Define the key-words and free text words for the different inclusion criteria and databases;
5. Search for literature in databases with defined key-words;
6. Deciding about relevance based on title, abstract and exclusion criteria;
7. Selection of articles based on full text;
8. Collect the information to reach the research objective;
9. Reflect on the selected literature;

2.4 Databases we will use

To make sure we would not miss a relevant article we selected three different databases for our review, two medical databases and one management science database. These three are selected because these are the databases that are most frequently used. We reflected our choice with a librarian of the University of Twente. Beneath is a short description of the three selected databases.

- Medline (articles from 1950 to august 2006);

Medline is for the most medical practitioners the most important database for finding useful (references of) articles. Medline is a service of the U.S. National Library of Medicine that includes 4500 medical magazines published in more than 70 countries. The database contains over 16 million articles back to the 1950s[8].

- Embase (articles from 1980 to august 2006);

Embase is a European biomedical database which contains bibliographic records based on scientific articles in the biomedical area and is especially strong in its coverage of drug and pharmaceutical research. Embase contains over 11 million records from 1980 to present. Although Embase is similar to Medline in that it contains bibliographic records of biomedical articles, Medline does not cover 1800 of the 4800 journals covered by Embase[9].

- EBSCO: Business Source Elite (articles from 1985 to august 2006).

Business Source Elite provides full text coverage for nearly 1,100 business publications and economics journals, including nearly 500 peer-reviewed publications. In addition to the full text, this database offers indexing and abstracts for more than 1,750 journals back to 1985. Business Source Elite contains full text from the world's top management and marketing journals[10].

Also relevant references to other studies in the selected articles will be traced and used.

2.5 Criteria

In this step we define the criteria we will use to select the relevant articles. We decided to formulate inclusion and exclusion criteria. The inclusion criteria will be used for searching through the databases. The exclusion criteria will be used for the selection of studies after the search through the databases is completed.

2.5.1 Inclusion criteria

1) Articles containing a model that deals with the design and/or control of a process;
2) 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;

[8] Handleiding voor het zoeken in Pubmed, LUMC, mei 2003
[9] www.embase.com
[10] www.support.ebsco.com

3) Articles using simulation based, descriptive or analytical models. We both look for models that tell us how to come to the optimal situation, and models that directly suggest a specific design;

4) 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, quality of work, and service.

2.5.2 Exclusion criteria

1) Articles using models that have the goal to optimize more than one department at a time;

2) Articles not published in peer-reviewed journals or published as a full paper in conference proceedings;

3) Articles concerning models that support medical considerations;

4) Articles with models primary concerning implementation of organizational change;

5) Articles suggesting models that primary forecast or predict demand or length of stay;

6) Articles containing models that primary demonstrate relationships;

7) Articles concerning software and/or hardware and IT with no direct effect on patient flows;

8) Articles suggesting models that describe an organizational structure.

2.6 Define the search strategy

To achieve a thoroughly search in the databases we will make use of the inclusion criteria. All the studies for the review must suffice the four formulated inclusion criteria. To achieve that we formulated per criteria different standard keywords and free text words.

The standard keywords (Pubmed: Mesh headings, Embase: Subject Headings and Ebsco: Subject terms) are determined by searching through these keywords. We will start with searching for the mesh headings and use these to find the standard keywords for Embase and Ebsco. In Medline the mesh headings are listed in a tree diagram with the broader headings (headings) at the top and the narrower headings (subheadings) as branches (see figure 1). The definitions of the mesh headings are also listed in this tree.

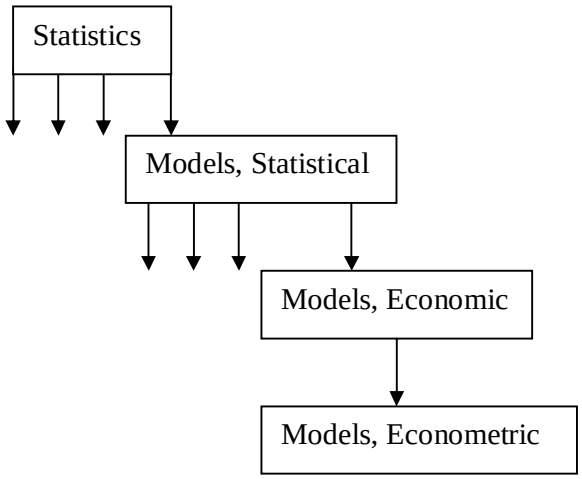

Figure 1: The tree diagram in Medline when starting with the Mesh Heading Statistics

We used this tree to determine the relevant mesh headings for our review. Embase and Ebsco make also use of tree diagrams. When we will find a possible relevant mesh heading, we first test it if the heading results in relevant articles. If not than the mesh heading is discarded.

Ebsco is not a medical database and that is why we choose to use slightly different free text words to make sure we only get articles concerning hospitals. The defined words can be found in Appendix A.

With the defined keywords and free text words we will search through the databases per criteria with the OR statement. This means that only one of the keywords or free text words needs to be found in the article to include the article for that criterion.

In the next step we will combine the results of the four criteria with the AND statement. This means that every article must contain one or more of the words defined for every criterion. In the next step we will combine the three databases and remove duplicates. The duplicates will be removed by Reference Manager. Reference Manager is a software programme that saves and manages all the founded references (title, author, abstract etc of the founded studies). This programme can also removes the duplicates in the references[11].

The results of the accomplished search are listed in Appendix B.

2.7 Collect the information to reach the research objective

After selecting the relevant articles we will determine for every study the results concerning the objective review. The information we will collect for the studies is listed in table 1. We decided to collect information in seven areas. The first five are areas with respect to the content and the last two are with respect to the quality of the study. For all the areas we determined several categories in which the study can fall. These categories are also listed in table 1. It could be that during the reading process we find out that some of the categories are not used or well defined. Because of that we will consider the categories again after reading all the articles.

When reading the studies and dividing them into the categories we ran into problems with the definition of conceptions of especially the last three categories. That is why we clarified these definitions. We also added some categories and items during the reading process to make sure we could reach our objective.

[11] More information of Reference manager can be found at www.refman.com

Table 1: The information that will be collected for the review

Item	Definition	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 indicators * 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*	* yes * no
Generic	*An article is generic when the model is usable in another hospital and/or department*	* yes * no

PART III: The Article

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 an 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 scenarios. 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 does 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 situation, and models that directly suggest a specific design	Articles concerning models that support medical considerations
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	Definition	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 indicators * 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 hospital 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 evaluation. 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.

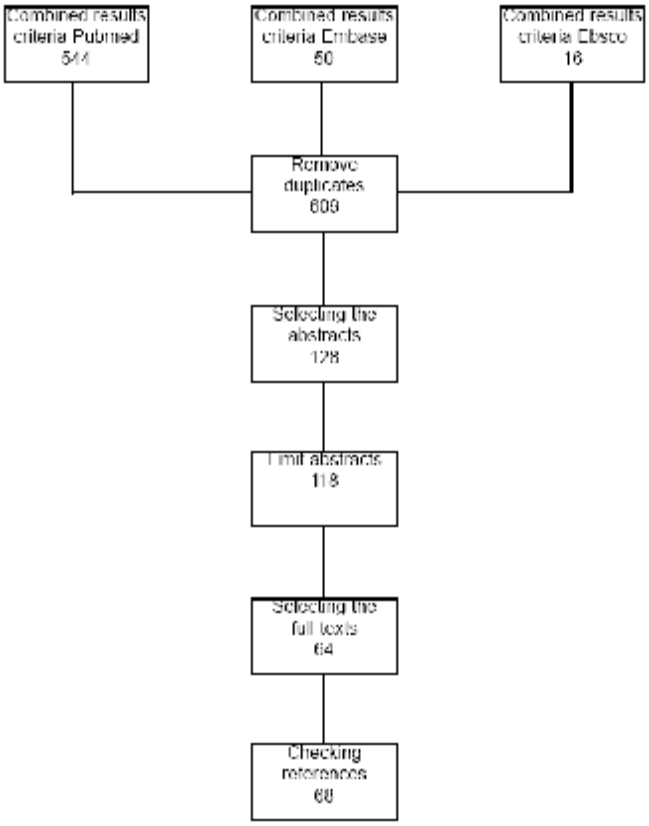

Figure 1 - Flow chart of the systematic review

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 the studies contained models that are validated in practice. Half of the studies are generic. Utilization is with 22% the outcome measure that is used most frequently, while also relevant outcome measures are costs, needed capacity, throughput time and waiting times. Figure 2 shows the number of articles for a type of model published per year. This graph indicates that through the years more articles on the subject are published, with a peak in 2003, especially for the computer simulation models.

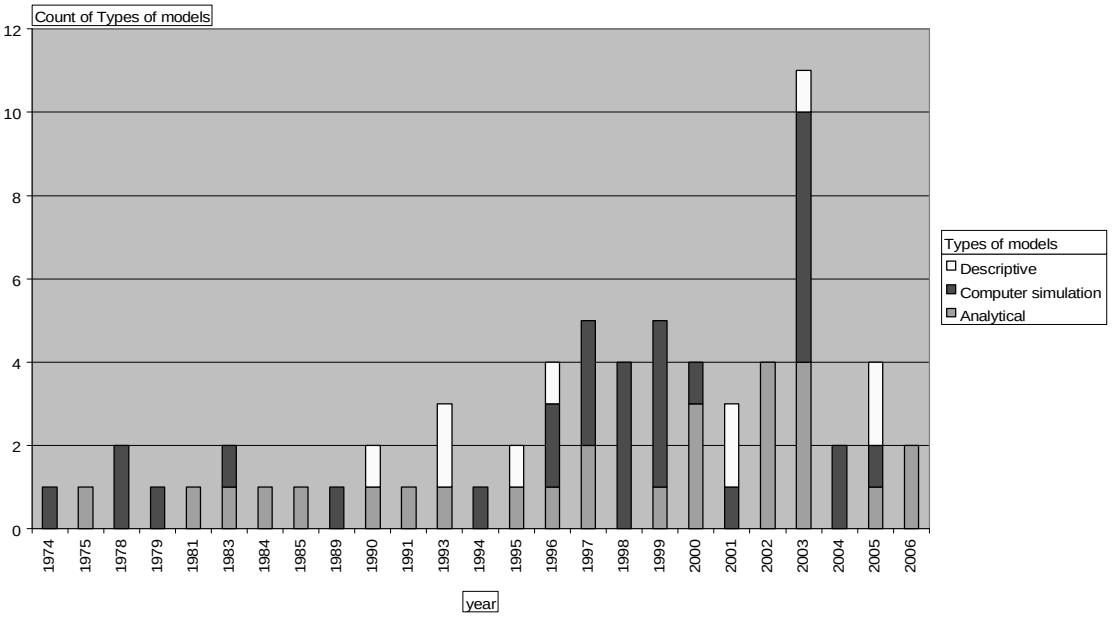

Figure 2 - Number of articles per type of model per year

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.

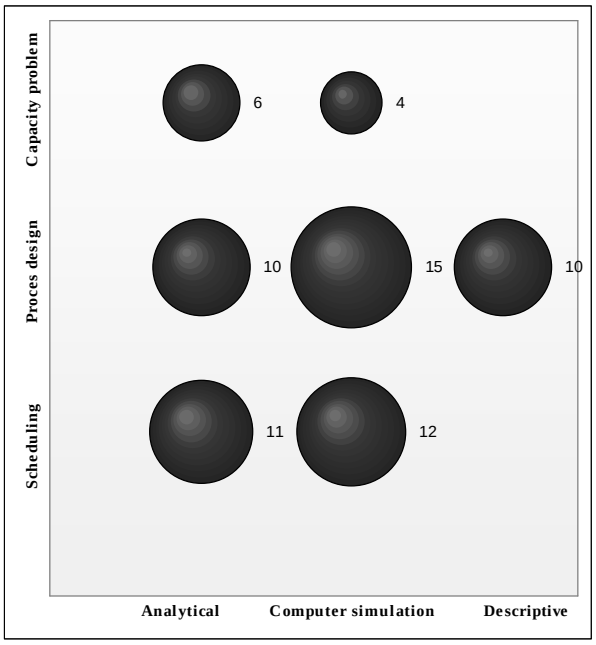

Figure 3 - Relation between type of problem and type of model

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 scenarios. 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 A. Search words

Standard 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 department	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

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

Appendix B. Results of the search

In this appendix the results of the search through the databases is imaged in this appendix
Figure 1 is a graphical display of the search process and the results of the search in Pubmed
Figure 2 is a graphical display of the search processes and the results of the search in Embase and Ebsco
Figure 3 images is a graphical display of the combination of the three searches

Figure 1: Search process and results Pubmed

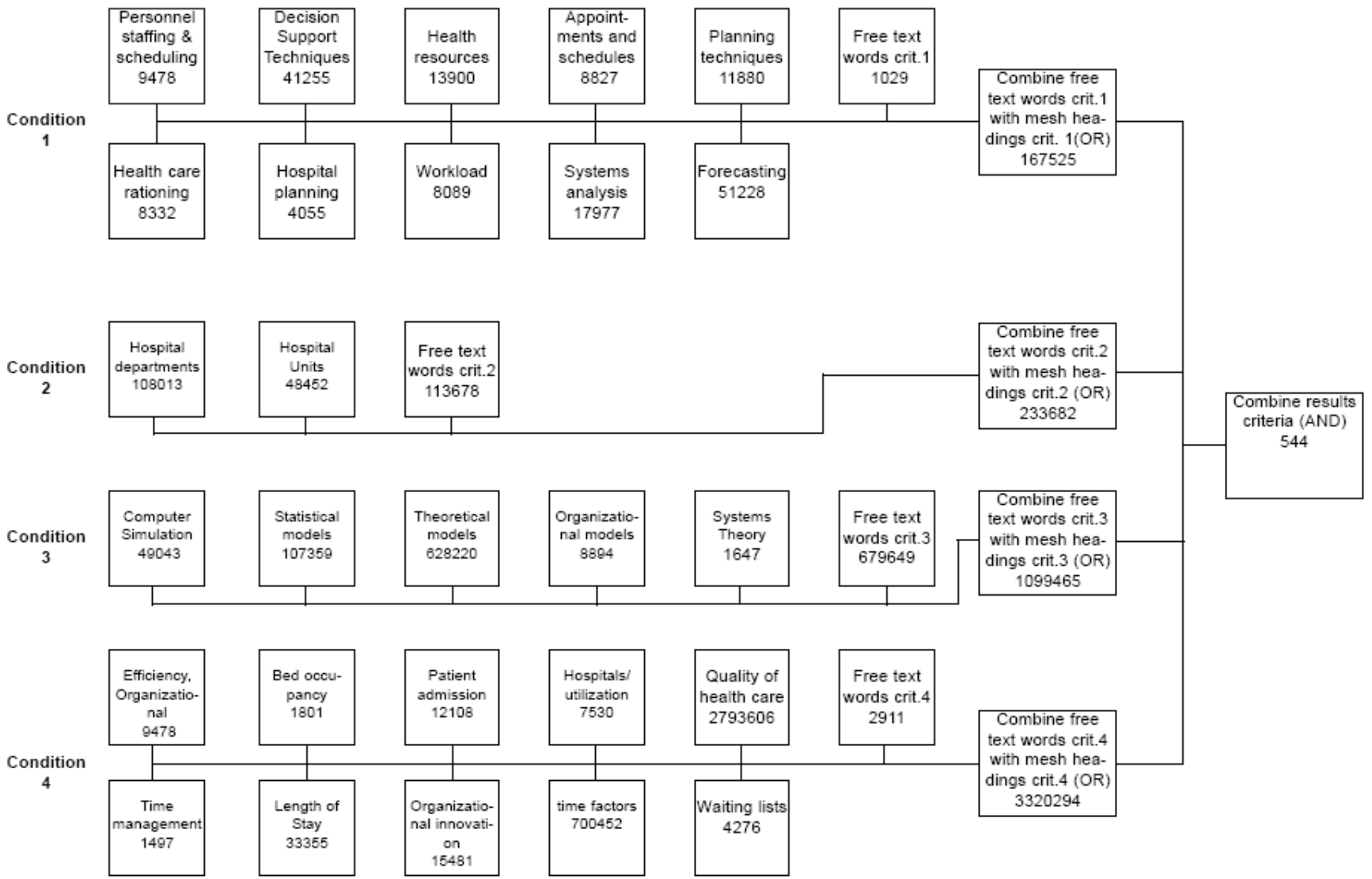


Figure 2: Search process and results Embase and Ebsco

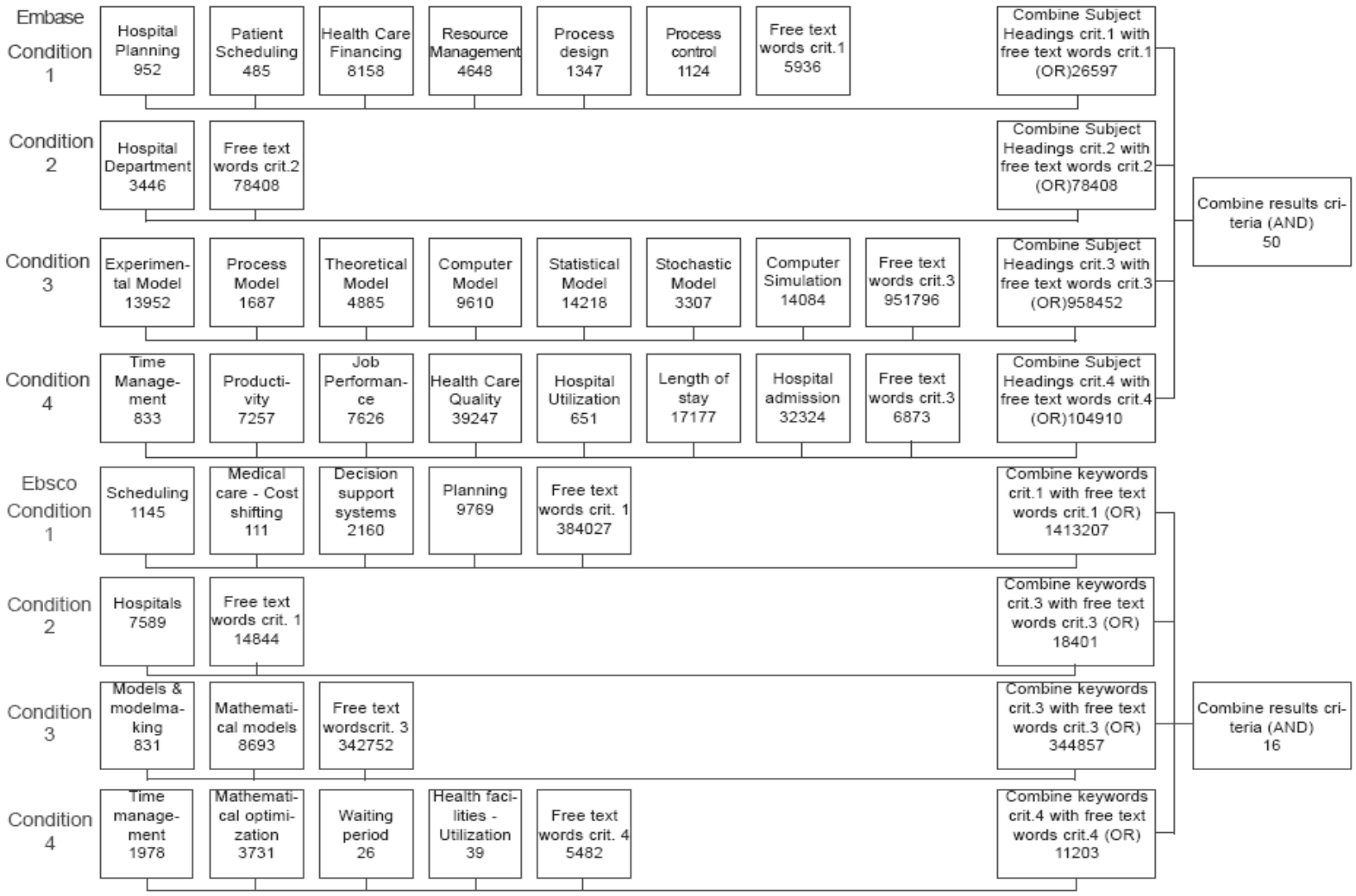
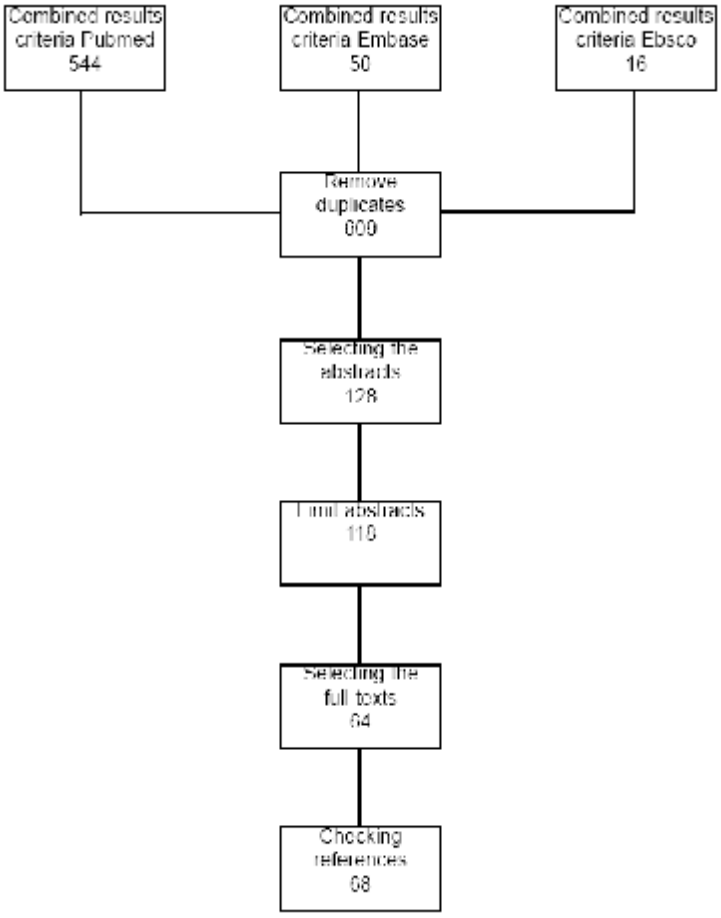


Figure 3: The combined results of the searches



Appendix C. Reflectieverslag

Ruim twee jaar geleden ben ik begonnen met mijn bacheloropdracht. Sinds die tijd ben ik tegen een aantal zaken opgelopen waar ik veel van geleerd heb. In mijn reflectieverslag zal ik een aantal van deze zaken toelichten en vertellen wat ik hiervan heb geleerd

Literatuuronderzoek
Tijdens mijn bachelor Technische Bedrijfskunde heb ik nooit een heel doorgronding literatuur onderzoek gedaan. De systematic review was dus ook helemaal nieuw voor mij. Na mij in te hebben gelezen begon ik in te zien hoe een systematic review in elkaar zit en de relevantie ervan in de gezondheidszorg. Over systematic reviews in de bedrijfskunde was weinig te vinden. Door de verschillen, die in het verslag zijn uitgelegd, konden we de methode voor de systematic review in de gezondheidszorg niet gebruiken en hebben we onze eigen methode gehanteerd op basis van de methode van Cochrane.

Opstellen van het protocol
Wat ik hier erg lastig aan vond is het duidelijk formuleren van de doelen. Ik ben er achter gekomen dat het heel belangrijk is om van te voren heel duidelijk te hebben welke kant je op wilt gaan met je onderzoek. Dat klinkt misschien heel logisch, maar toch vond ik het niet zo gemakkelijk. Gedurende je onderzoek kom je namelijk steeds meer over het onderwerp te weten en kun je andere ideeën krijgen over de richting van je onderzoek. Uiteindelijk hebben we ons dan ook niet helemaal aan het eigenlijke protocol gehouden, met name op het gebied van de informatie die wij relevant achtte om te verzamelen uit de artikelen. Gedurende het onderzoek hebben we de classificatie categorieën aangepast en er een aantal toegevoegd. Dit kwam mede door het feit dat er een aantal begrippen niet helder geformuleerd waren waardoor er bij het classificeren onduidelijkheden ontstonden. Ook kwamen we tijdens het lezen van de artikelen weer op nieuwe categorieën. Dit heeft ervoor gezorgd dat een aantal artikelen opnieuw gelezen moest worden om alsnog een goede classificatie te maken. Dit heeft veel extra tijd gekost en het was makkelijker geweest om dat vooraf beter te bepalen. Hoewel dit dan wel weer het probleem met zich mee brengt dat je dan niet altijd genoeg van het onderwerp af weet.

Zoeken door de databases
Het bepalen van de zoekmethode en het daadwerkelijke zoeken in de databases was in het begin wat lastig omdat ik hier nog niet zoveel mee gewerkt had. Ik ben toen langs geweest bij een bibliothecaris van de Universiteit en hij heeft mij nog het een en ander uitgelegd over de databases. Op de website van Puber staat ook heel duidelijk aangegeven hoe je de database kan doorzoeken. De andere databases leken hier gelukkig ook wel redelijk op. Ik moest niet zo lang geleden voor een mastervak een klein literatuur onderzoek doen. Ik heb toen de methode gebruikt die ik ook heb gebruikt tijdens mijn bacheloropdracht, alleen wat minder uitgebreid. Dit heeft me erg geholpen om relevante artikelen te vinden.

Van te voren hadden we niet echt een schatting hoeveel artikelen er uit onze zoekmethode zouden komen. Ons doel was vrij breed dus het leverde uiteindelijk rond de 600 artikelen op. Dit zijn er aardig wat en dit heeft ook gezorgd voor een lang selectieproces. Bij het selectieproces is het noodzakelijk om veel met elkaar te overleggen en te discussiëren. Ook

hier gaat veel tijd inzitten, zeker ook omdat bij elkaar komen niet altijd makkelijk was gezien de afstanden en de verschillende agenda's. Ik heb ervaren dat het vaak lastig is om hier een geruime tijd achter elkaar bezig te zijn met het beoordelen van de artikelen. Op een gegeven moment word je moe en krijg je minder discussie, waardoor de betrouwbaarheid van de systematic review af kan nemen.

Tijdsplanning

Gedurende het onderzoek bleek dat de tijdsplanning die ik van te voren had gemaakt niet te halen was. Het bleek dat het onderzoek veel groter was dan dat we in hadden geschat en het werd dus ook eigenlijk meer dan een bacheloropdracht. Ik ben er toch mee doorgegaan omdat ik het erg interessant vond om aan mee te werken en erg benieuwd was naar de resultaten. Onderstaande tabel geeft aan hoeveel tijd ik voor de bepaalde onderwerpen in had geschat nodig te hebben. De eerste drie stappen komen goed overeen met de werkelijkheid. Stap 4 en 5 hebben veel langer geduurd. Door de grote hoeveelheid gevonden artikelen heeft het selectieproces heel veel tijd gekost. Stap 7 is in de vorm van een artikel gegaan. Dit heeft ook iets meer tijd gekost dan daarvoor was geschat. Het bleek ook hier dat het helder formulieren van goede definities erg lastig en erg belangrijk is.
Wat ook heeft meegespeeld in het overschrijden van de tijdsplanning is het feit dat het geen full time onderzoek was. Het kost altijd weer even wat tijd om weer in het onderzoek te duiken. Er zijn een aantal redenen te noemen dat het geen full time onderzoek kon zijn. De eerste reden is dat ik aan het begin van mijn onderzoek aan mijn been ben geopereerd. Ik had verwacht dat dit niet zo heel veel vertraging zou opleveren, maar dat was in de praktijk toch anders.Het feit dat je niet zo mobiel bent kost toch behoorlijk wat energie. Vrij snel daarna ben ik in de Introductie Kommissie van de Universiteit gegaan. Dit nam ook weer een deel van mijn tijd in beslag (met name in de zomer). Ook het feit dat je met iemand samen werkt en allebei nog een andere agenda hebt, zorgt ervoor dat full time werken erg lastig wordt.

Wat?	**Benodigde tijd**
1. Maken van een plan van aanpak	30 uur
2. Bespreken plan van aanpak met interne begeleider	1 uur
3. Opstellen protocol voor systematische review	50 uur
4. Het doorzoeken van de verschillende databases en het selecteren van artikelen	80 uur
5. Het beoordelen van de relevantie van de artikelen	70 uur
6. Bespreking resultaten met interne begeleider	1 uur
7. Het kritisch analyseren van de gevonden artikelen en maken van een verslag hiervan	175 uur
8. Bespreking verslag met interne begeleider	1 uur
9. Afronden van het verslag	10 uur
10. Het maken/houden van colloquium	5 uur

Begeleiding

Wat ik erg leerzaam vond tijdens mijn onderzoek zijn de gesprekken met de begeleiders. Deze gesprekken waren vaak erg vehelderend en interessant. Met name in het begin vond ik het lastig om me goed in het gesprek te mengen. Dit zou ook wel kunnen komen door het feit dat er van mijn kant toch wel een kennisachterstand is. Naarmate ik meer in het onderwerp zat werd dat wel iets makkelijker.

Artikel
Ik vond het erg leerzaam om mee te werken aan het schrijven van een artikel. Ik vind het erg lastig om goed op papier te zetten wat ik precies bedoel en al helemaal als dat in het Engels gaat. Bij het schrijven van een artikel is het heel belangrijk dat er duidelijk staat wat er bedoeld wordt. Door het schrijven van dit artikel gaat dit wat makkelijker, mede door de goede kritiek van de begeleiders.

Conclusie
Ik heb de afgelopen twee jaar veel van deze opdracht geleerd. Het onderwerp sprak me erg aan, mede ook door het feit dat het op het moment ook erg veel bruikbaar onderzoek op dit gebied wordt gedaan en ook nog heel veel gedaan kan worden.

De opdracht was eigenlijk wat te groot voor een bacheloropdracht en heeft onder andere daarom zolang geduurd. Soms is het dan wel lastig om weer de goede motivatie te vinden.

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