Applications of Operations Management in Healthcare
- A Case Study of an Ophthalmological Department

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Abstract

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Healthcare organisations are facing a number of challenges as demand for care is increasing while resources remain scarce. This results in long waiting times causing patient dissatisfaction, increased healthcare costs, and broader costs to society as a whole. The research presented in this study investigates and analyses issues in healthcare production at an outpatient ward in Gothenburg, Sweden. The ward is facing long waiting times and is struggling with an unsatisfactory utilisation of current registered nurses and nursing assistants. The study also suggests and analyses possible actions of improvements from the field of operations management in order to address these issues.

By using the qualitative method of shadowing, key factors contributing to the lowered caregiving capacity in the daily work of registered nurses and nursing assistants are described. It is shown that administrative tasks, some of which require little or no medical expertise, are a time consuming element in the daily work of registered nurses. Furthermore, difficulties in planning the production at the ward result in a non-optimised utilisation of valuable personnel resources. Based on these findings, the applicability of measures from queuing theory and task shifting is explored. These examples indicate that operations management applications may have a positive impact on the issues observed at the ward.

Acknowledgements

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1. Introduction

1.1 Background

In recent years, the healthcare systems across many developing countries have been facing a number of challenges. Ageing populations require higher volumes of care, and new treatments and medicines result in increasing costs for governments and health service providers. In 2012, the unweighted average of healthcare spending to GDP was 8,7 % in EU28, significantly higher than the 7,4 % spent in 2000 (OECD, 2014). Patients in many European countries are also facing long waiting times for health services. Long waiting times generate dissatisfaction among patients, as well as broader economic and social costs for society as a whole due to work absenteeism and lower health related quality of life (Derrett et al., 1999; Hoel & Sæther, 2003; Hiidenhovi, 2002).

These critical issues can be addressed in a number of ways. In Sweden, policy developments intending to introduce market-based elements to the healthcare sector, such as strategies to increase competition and incentivise productivity improvements, have been made. On an organisational level, methods from the field of operations management used in industry such as lean production and total quality management have been identified as ways to improve cost efficiency and availability. More recently, albeit to a lesser extent, "production planning and control" (PPC) has been implemented in the healthcare sector, in some instances yielding promising results (Plantin & Johansson, 2012). Historically, the healthcare policy principles of the right to high quality and accessible healthcare for all individuals have been achieved by expanding the sector as demand has grown. In the 1960s and 1970s this led to the increase in costs being higher than the increase in "produced output". However, since the mid 1980s, attempts to improve healthcare have shifted away from increasing the share of GNP allocated to the sector, and towards the use of managerial tools as measures to increase productivity (Trägårdh & Lindberg, 2004).

A study of McKinsey & Co. (1996) illustrates one example of productivity differences between different healthcare systems by comparing diabetic care in the UK and in the US. Although the input, calculated as working hours for physicians and registered nurses (RNs), is lower in the UK, the mortality rate for patients in the age 15-34 is 47-81% of the mortality rate for the corresponding group in the US. Therefore, productivity defined as the resource inputs needed to achieve a given level of output was higher in the UK. This shows that different ways of producing healthcare services result in different productivity levels.

1.2 Problem Discussion

Sahlgrenska University Hospital (SU) was founded through a merger of Mölndal Hospital, Sahlgrenska Hospital and Östra Hospital in 1997. SU provides emergency and basic care for the Gothenburg region with a population of 700.000, and provides highly specialised care for West Sweden, which has a population of 1.7 million inhabitants.

In 2013, the Department of Ophthalmology at Mölndal Hospital (MH) had a total of 198 employees. 51 of these employees were doctors, and the other 147 were a combination of different professionals including RNs, nursing assistants (NAs), and opticians (Västra Götalandsregionen, 2014). The doctors, RNs and opticians of the department are specialists in ophthalmology, i.e. medical and surgical eye problems. In 2013, a total of 44800 doctor visits and 6800 operations were conducted by the department. The average patient stay for these operations was 2.2 days. An internal report investigating the Department of Ophthalmology during the years 2013 and 2014 shed light on a range of problems including high employee stress levels, long patient lines and recruitment issues (Västra Götalandsregionen, 2014). The internal report led to further investigations at unit level. An analysis of staff capacity in one of the different department's wards was made by internal logisticians at SU. The report showed that productivity was constrained by low employee utilisation rates, i.e. low caregiving capacity in relation to the total number of employee work hours.

The studied unit referred to as "the ward" is an outpatient ward, meaning that they provide care for patients who receive medical procedures that do not require an overnight stay. The majority of the patient visits at the ward are planned, but the ward also provides emergency care. The ward consists of 21 RNs and seven NAs, each of which is divided into different teams where each team has its own type of duties and patients. The ward's unsatisfactory level of productivity has resulted in long waiting times for several categories of treatments. As the ward is subject to budgetary constraints and has experienced difficulties increasing their staff due to the scarcity of people with desirable skills and competences, efforts in increasing production capacity are focused on increasing the utilisation of their current caregiving employees. According to the internal report of the specific ward using figures from 2014, the average utilisation rate for the caregiving staff is 74 % during patient-oriented shifts. For doctors, the utilisation rate is higher whereas the productive time is an even lower fraction of the RNs' total work hours.

A general key characteristic and dilemma for hospital organisations is the limited ability of hospital management to control the production processes that are in the hands of specialists (De Vries, Bertrand & Vissers, 1999). A similar problem exists at the Department of Ophthalmology where the management claims to have an insufficient understanding of the production processes, leaving them unable to fully address the problem of unsatisfactory utilisation of personnel resources. However, the management believes that the low utilisation rate is a result of production processes including non-value creating activities and the poor coordination of different resources.

In 2011 SU embarked on a program to implement PPC systems for all its units. Although the Department of Ophthalmology has attempted to partly adopt the method, the concept of systematically enabling the demand for care to set the pace of production has not yet been fully embraced. Instead, the availability of necessary staff and facilities continue to determine the intended produced quantity. As a result, one of the ward's stated priorities is to successfully implement the production planning approach.

For the managers at MH this study will give insights in operational matters of which they need a better understanding when working towards increasing productivity. The study will also act as concrete advice on how problems preventing the productivity from reaching its full potential can be approached using theory from operations management, and thereby potentially be solved. In doing so, the research will enrich existing theory and help bridging the gap between theory and practice. SU has made deliberate efforts in moving towards standards and methods more often used in industry, and the research presented in this thesis aims to provide help and guidance on how to maximise the outcome of these efforts. By increasing productivity, the high costs of purchased care today can be reduced. Furthermore, with a better understanding of how daily activities are carried out by the caregiving personnel, the management at the department will be able to develop appropriate and timely initiatives to manage high employee stress levels. The benefits of production improvements are also of major importance for society as a whole, as increased productivity can improve healthcare availability. This would have a positive impact on minimising the economic and social costs related to long healthcare waiting lines.

1.3 Purpose

This study aims to investigate and analyse issues in utilisation of personnel resources in healthcare production at an outpatient ward. In drawing upon theory from the fields of Management and Industrial Management, the research in this study also intends to suggest and to analyse possible actions of improvement.

1.4 Research Questions

This study answers the following questions:

1. *Which factors in the daily work of registered nurses and nursing assistants lower their capacity for caregiving activities?*

2. *How can operation management methods be applied in order to increase the capacity for caregiving activities among the registered nurses?*

Delimitations

The description and analysis of factors affecting the capacity for caregiving activities among registered nurses and nursing assistants exclude issues that are considered strictly technological, medical, or in other ways beyond the scope of operations management.

2. Theory

In this section, the reader will be familiarised with some operations management theories. Furthermore, presentations of several methods within operations management that can be applicable in order to answer research question number two will be described.

2.1 Operations Management

Operations management is the set of activities that creates goods and services by transforming inputs into outputs. This includes targeted efforts related to improving product performance and variety, managing quality and delivery time, enhancing customer service and creating operational flexibility. Effective operations management practices give the potential for organisations to improve revenue while also enabling goods and services to be produced more efficiently (Scardilli, 2014). The field of operations management involves concepts such as total quality management, lean production, supply chain planning and control, work design, queuing theory, and production planning and control (Heizer & Render, 2001; Slack, Chambers & Johnston, 2001). The theoretical framework used in this study is based on the operations management fields of production planning and control, task shifting, and queuing theory.

2.2 Production Planning and Control

Production planning and control (PPC) refers to planning of production and manufacturing processes in a company. PPC can be described as the coordination of supply, production and distribution processes in a manufacturing system with the object of achieving specific delivery ability while minimising costs (De Vries, Bertrand & Vissers, 1999). This means that production factors have to be put to good use and that scarce resources have to be especially well utilised. PPC-systems reflect an order of different planning levels with master production scheduling at the highest level, followed by capacity planning and material requirements planning at the second and third level, and shop floor control, manufacturing execution systems and supplier systems at the lowest short term level. Together, the different levels of PPC manage technical and logistical problems related to process planning, scheduling, ordering materials, lead times, and product delivery (Tyagi, Jain & Jain, 2013).

2.2.1 Production Planning and Control in Healthcare

Compared to methods such as lean production and total quality management, the application of PPC in healthcare is at a stage of limited maturity. Given its focus on both costs and the output, PPC is a particularly promising method in improving productivity in the healthcare sector. An action research study carried out at Skaraborg Hospital Group explored the benefits

of simple and rough PPC models, implemented stepwise (Plantin & Johansson, 2012). The models can be categorised into three groups: production targets, planning processes and matching production plans and capacity. At one of the units (a ward for elective surgery) the specific measures taken involved the levelling of patient flow, scheduling complicated surgery for the beginning of the week, and creating a consistent level of production. Improved coordination of resources through matching doctor availability and operation room capacity was another important action, leading to improved utilisation of resources. At the other unit (an outpatient clinic), the production capacity was mainly determined by the varying availability of doctors and not the actual demand from patients. This often resulted in either under- or over-utilisation of personnel resources. To address this issue, historical demand figures were used as a preliminary estimate of what production capacity would be necessary to meet the demand. With this in mind, a production plan based on two doctors working throughout the whole day was created.

For both units, the mean lead times and the standard deviations of lead times decreased substantially. At the ward for elective surgery, the variation in daily admissions was reduced from levels of 0-12 patients per day, to 4-6 patients per day (ibid).

The study shows that simple operations management methods and a shift towards a more demand oriented approach can result in considerable improvements in patient waiting times.

2.3 Task Shifting

Task shifting is a rational redistribution process whereby specific tasks are moved from higher qualified health workers to health workers with fewer qualifications and training (WHO, 2007). Task shifting enables a more efficient use of human resources and contributes to an ease of bottlenecks in service delivery. In cases where additional human resources are vital, task shifting may involve delegation of clearly specified tasks to newly created professions with specific competency-based training (ibid). In order to counteract health resource shortages by delegating tasks from more specialised to less specialised health workers, the Zambian Ministry of Health has maximised the potential of healthcare providers (Morris et al., 2009). The model of task shifting requires a transfer of specific tasks to other providers who have been trained to carry out the task. By an introduction of the task shifting model at a specific hospital in Zambia, tasks have been shifted from more specialised towards less specialised health providers. Clinical officers now manage a certain set of tasks previously performed by doctors. To subsidise the task shift, tasks previously performed by clinical officers were instead shifted to nurses. In turn, nurses receive support on basic tasks

by newly trained professionals known as peer educators (ibid). One of the main concerns before implementing task shifting was that the quality of care could deteriorate from a higher clinic volume. However, after the implementation, results showed that the examined task shifting increased several basic quality indicators despite an increase of the clinic volume (ibid).

Duffield, Gardner and Catling-Paull (2008) have written a report about transformation in the healthcare workplace. Due to the range of economic pressures faced in recent decades, and the implementation of strategies to alleviate these pressures, the workforce has undergone significant changes to meet current needs. A lot of work has been picked up by RNs, today an increasingly scarce and expensive resource. As a result from this transformation, the use of RNs' valuable time and skills has changed. A lot of non-direct patient care tasks are managed by RNs - tasks which less qualified staff could manage instead. One example is the increased level of documentation, which is currently managed to a great extent by RNs. What has to be done, according to Duffield, Gardner and Catling-Paull (2008), is a redesign of work responsibilities where RNs should use their skill where it is most needed - provide patient care. Many other activities should be delegated to less qualified staff. In order to allocate the RN staff resources more effectively, an identification of the RNs work is needed (ibid). Firstly, a mapping process helps to detect which activities managed by RNs that could be undertaken by other workers. The second step is to adopt work redesign in order to involve support workers in the selected direct and indirect patient care activities. Lastly, the scopes of practice among the different professions have to be clarified.

Another study highlighting a change and adjustment of RNs' work activities in order to increase their professional patient care was written by Lundgren and Segesten (2001). The authors have investigated in the RNs allocation of time spent fulfilling nursing and caregiving roles at a university hospital in Sweden. Their objectives were to investigate how the nursing time was allocated to various activities, how the RNs organised their nursing time and whether the allocation of nursing time had changed over time. To meet the specified aims, non-participant observations were performed during two different occasions with a two-year interval. The observation took place at a 22-bed medical-surgical ward, ten days per observation. Lundgren and Segesten (2001) specified seven different categories in order to be able to divide the various activities into one of them. The specified categories were: direct patient care, indirect care, rounds, service, shift reports, patient administration and general management and personal activities. Through data analysis, it was found that the RNs spent

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on average 37 % - 39 % on direct patient care, depending on used categorisation system. Patient administration and general management were allocated between 23 % and 25 %, with minimum and maximum figures between 12 % and 42 %. Patient administration and general management was found to be the activities that could be reduced from RNs to increase their professional patient time (ibid).

The authors suggest that part of the RNs administration and general management work could be handled over to support personnel and that small changes in how RNs spend their work time could increase their time for professional patient time.

2.4 Queuing Theory

Queuing theory was developed in the early 20th century, originally with the purpose of economically planning the service capacity of a telephone exchange. The models could provide exact mathematical relationships between customer demand, service rate, and customer queue, while taking into consideration variation in demand and service times, which made it applicable to the telephone exchange staffing issue (Palvannan & Teow, 2012). There are also various applications of queuing theory in healthcare. These are described in 2.4.1.

Most models used in queuing theory focus on finding the level of service that a firm should provide, in order to achieve a certain waiting time. For instance, grocery stores have to decide how many cash registers should be open, a gasoline station needs to think about how many pumps should be available, and an airline company needs to consider how many counters they should open during check-in (Balakrishnan, Render & Stair, 2007). A common approach to application of queuing models is attempting to minimise costs resulting partly from providing a given level of service, and partly from customer dissatisfaction generated from low availability, i.e. long waiting times. By approximating the two types of costs, the decision makers can find the level of service resulting in a minimisation of total costs (Ozcan, 2005).

Queuing models are often classified using "Kendall's notation". The three symbol notation has the form of A/B/s, where A is the arrival probability distribution, B is the service time probability distribution and s is the number of servers. In this research paper, the M/M/s queuing system is applied. The M/M/s system is suitable when arrivals are approximated using the Poisson probability distribution, service time is estimated with the exponential probability distribution and the number of servers assume values other than one (Balakrishnan, Render & Stair 2007).

The Poisson distribution is a discrete probability distribution showing the probability of a certain number of events occurring within a fixed interval of time or space. For the Poisson distribution to be applicable as arrival rate estimation, four criteria need to be met. (1) The average arrival rate is known, (2) the average rate does not differ between different time intervals, (3) the different arrivals are independent from each other, and (4) more than one arrival cannot occur during an interval when the interval size approaches zero. The Poisson distribution is related to the exponential distribution. In a scenario where the arrivals occur according to a Poisson distribution, the time between the arrivals follow an exponential distribution. In a M/M/s queuing model context, the exponential distribution describe the probabilities of different service rates, given a mean value.

Besides the previously mentioned conditions there are three more queue characteristics necessary for the usability of the M/M/s queuing system. Firstly, the order of service follows a "first-in, first-out"(FIFO) system, meaning that patients are served in the same order as in which they arrive. Other queuing system may for instance be based on rules prioritising fast errands or patients that are in an especially urgent need of care. Secondly, the queue can not have limits affecting its potential length. Thirdly, the patient is served at one station and then exits the system. If these criteria are fulfilled we can calculate several different queuing measures given inputs on arrival rate (λ), service time (μ) and number of servers (s).

1. Average server utilisation in the system:

$$\rho = \frac{\lambda}{s\mu}$$

2. Probability that there are zero customers or units in the system:

$$P_0 = \frac{1}{\left[\sum_{k=0}^{s-1}\frac{1}{k!}\left(\frac{\lambda}{\mu}\right)^k\right] + \frac{1}{s!}\left(\frac{\lambda}{\mu}\right)^s\frac{s\mu}{(s\mu-\lambda)}}$$

   The sigma sign ($\sum$) means that the equation is iterated s-1 times, where 1 is added to k for each iteration. The faculty sign (!) means that k is multiplied with each positive integer lower than or equal to k, i.e. k! = k(k-1)*(k-2)*(k-3)*...*(k-(k-1)

3. Average number of customers or units waiting in line for service:

$$L_q = \frac{\left(\frac{\lambda}{\mu}\right)^s\lambda\mu}{(s-1)!\,(s\mu-\lambda)^2}P_0$$

4. Average number of customers or units in the system:

$$L = L_q$$

5. Average time a customer or unit spends waiting in line for service:

$$W_q = L_q / \lambda$$

6. Average time a customer or unit spends in the system:

$$W = W_q + 1/\mu$$

7. Probability that there are *n* customers or units in the system:

$$P_n = \frac{\left(\frac{\lambda}{\mu}\right)^n}{n!} P^0 \text{ for n} \leq s$$

$$P_n = \frac{\left(\frac{\lambda}{\mu}\right)^n}{s! s^{(n-s)}} P^0 \quad \text{for n} > s$$

As mentioned above, when the criteria for M/M/s are fulfilled, different queuing characteristics can be calculated. Table 5 displays the different characteristics that the M/M/s queuing system can calculate from the equations at previous page.

Table 1
Operating characteristics of queue system

Lq: average number of patients waiting in line for service
Wq: average time a patient spends in line waiting for servers (in hours)
p: average server utilisation in the system

2.4.1 Queuing Theory in Healthcare

There are many areas in healthcare production that are suitable subjects for queuing model analysis. When improving the performance of emergency care units, queuing models are useful as tools for making decisions on staffing and facilities design (Singh, 2006). A study by Agnihothri and Taylor (1991) shows how queuing models can be applied when staffing a centralised appointment department, taking into consideration the required server utilisation and patient waiting time. The appointment department managed to decrease their complaints from patients drastically, by simply using queuing modelling to plan their staff allocation more efficiently. Palvannan and Teow (2012) managed to estimate the number of post-recovery beds required for a certain type of patient group, after completing their surgery. By setting the proportion of patients who would need to wait for their post recovery placement as a very low percentage, it was possible to find the optimal number of beds to set aside for the specific group of patients.

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3. Methodology

3.1 Research Approach

Since the term descriptive research means that the research is used to describe a phenomenon, the foundation of this study is of descriptive character. When the research moves on to explain the applicability of other research and theories to the situation at MH, the study will also include exploratory elements.

Given the practical orientation of this case study, and the fact that theory and data are gathered and explored somewhat simultaneously, the logic of abductive reasoning is especially well suited for this research process. Abductive reasoning can be explained as the process of going from an observation to a simple and likely explanation, or hypothesis (Kovács & Spens, 2005). One benefit of abductive reasoning is that the researcher can remain open to the empirical material and on the same time maintain a solid base of theoretical framework (Patel & Davidsson, 2011).

3.2 Type of study and data collection

In order to answer the stated research questions, a case study method has been employed. The most appropriate way to gather primary data for this case study is by using a combination of qualitative and quantitative research methods. The availability of quantitative data is not alone sufficient for answering the research questions, and the time required for gathering statistically reliant data explaining the observed findings would be outside the time frames given for this project. The hospital's production processes are functions of a large number of intertwined factors, and investigating these using a strictly quantitative method would be overwhelmingly complex. Furthermore, the qualitative method will provide flexibility in adjusting the focus of the observations as the project proceeds. The combination of qualitative and quantitative methods goes well with the theoretical framework employed for the research presented in this study. Operations management involves many aspects of the operations of an organisation, making the studies of the subject highly multi-disciplinary (Scardilli, 2014). For the aspects of operations management that emphasise employee and organisational performance, qualitative methods are especially useful. For the aspects closer to process engineering, quantitative methods are also needed for providing meaningful information.

The applied technique to collect qualitative data has mainly been ethnographic-inspired. The aim is to examine what actually happens at the ward and therefore, ethnographic fieldwork is

the scientific method of choice. Ethnography is a scientific and investigative method that through rigorous research attempts to avoid inaccurate data, for example when studying institutions. The main instruments for collecting data are the researcher's eyes and ears (LeCompte & Schensul, 1999). An ethnographic research approach requires an intensive involvement in an organisation's day-to-day activities in order to give the researcher the point of view of an insider. To attain this perspective, the ethnographer can adopt various roles, e.g. participant-as observer or observer-as-participant (Bryman & Bell, 2011).

3.2.1 Shadowing

In this case study, primary data is collected using the ethnographic technique called "shadowing". Data collection has also been performed using secondary data. Shadowing is in some ways similar to traditional field research techniques, for instance participant observation, and they can sometimes be difficult to classify and distinguish. Czarniawska (2007) claims that they often overlap each other as all direct observations are in some way participatory. Shadowing implies that the researcher closely follows a predetermined object "like a shadow", over a predetermined time period. The great potential benefit of shadowing as a qualitative research method is that its data is often more detailed than data gathered from many other research methods. This can add new perspectives to organisation research (McDonald, 2005). Another advantage of shadowing as a research method is that it enables observations to be made in a context of complex and professional activities where it would otherwise be impossible for most researchers to gather data through participant observations (Czarniawska, 2007).

McDonald (2005) describes the shadowing period as a process where the researcher should ask questions for clarification as well as for revealing a purpose. Throughout the shadowing process, the researcher should write notes about what takes place. Everything from conversational content, duration for different events, body language, to mood of the shadowed person should be noted depending on the research objectives. The collected data creates the foundation for the analysis and is therefore a critical step in the research process.

Due to the nature of this study, an appropriate method is to combine the role as an observer-as-participant and as a complete observer. Observer-as-participant means that the researcher is mainly an interviewer, and that the observations involve very little participation (Bryman & Bell, 2011). A researcher being a complete observer means that the researcher does not interact with the members of the organisation or any other people at all. The people in the

research environment do not have to take the researcher into account, giving the observation an unobtrusive character (ibid).

According to Babbie (2001), the choice of observation method should depend on the research situation. The researchers' own understanding of the situation is the most important factor to take into consideration. In the case of this study, it is important to not interfere the RNs and NAs in during their patient appointments, as they need to assure a certain level of care quality. Therefore influences from complete observation could be considered a legitimate way of adapting the method to the context. However, the RNs and NAs can provide valuable information about their working processes from discussions in the corridors, coffee breaks et cetera, and in these situations the observer-as-participant approach is also a legitimate approach. Therefore, throughout the shadowing process, short unstructured interviews were conducted with the nurses depending on their time, willingness to help, and area of expertise. This made it possible to enrich data collected from observations when acting as complete observers would not have given a full understanding of the situation.

All RNs and NAs included in the study were informed about the shadowing in advance. During the period of shadowing, the nurses informed their patients about the study in order to make the patient feel comfortable. They emphasised that the focus of the observation was the nurse and not the patient.

During the whole shadowing process, field notes were collected on prepared forms. In the field notes, events of interest for the study were recorded, i.e. factors that could potentially contributing to answer the first of the two research questions. Events recorded could be the duration of different activities, specific events of interest, time consuming activities and opinions from RNs and NAs. Each shift's schedule was studied in advance in order to facilitate the comparison of an appointment's planned and actual time. Three category stacks were configured in the form: the shift's scheduled patient assessments, the actual time used for each activity and the activities not seen in the schedule (e.g. administration). Each activity was noted and clocked in five-minute intervals. The handwritten forms and notes were retrospectively translated and processed into excel sheets where utilisation rates could more easily be calculated and aggregated.

3.2.2 Secondary data

In order to obtain a deepened understanding and knowledge within the research area, findings and theory from other studies have also been used. The study of secondary data took place mainly in the beginning of the research process in order to explore the topic and to better understand the problems that had been described by the supervisors. Secondary data in the form of scientific articles, academic reports and theoretical literature have been downloaded through trusted databases such as Google Scholar, PubMed and Emerald. A systematic approach with carefully chosen keywords has been used when studying existing research material. Keywords used in the searches were for instance "production planning and control", "task shifting within healthcare" and "observational studies in healthcare". Confidential data shared by the supervisors has also been useful in order to gain knowledge and awareness about the problems and challenges faced by MH. Data produced by SU and by management consultancies has also given valuable statistical information, allowing the research to avoid rough estimations and data biases.

3.3 Sample

The selection of objects to study may have an impact on the outcome of this research. In this study, a purposive sample approach was deliberately chosen because of the focus on specific nurse shifts. In purposive sampling, researchers do not seek to sample participants on a random basis. Instead, the researchers sample participants in a strategic manner with the research question in consideration (Bryman & Bell, 2011). This statement corresponds well to the report's purpose; relevant participants are shadowed during relevant shifts in the context of this thesis.

Another reason for applying purposive sample method is to select specific shifts enriching the study. For instance, to shadow an NA during a washing-shift does not benefit the study, and consumes valuable time. To facilitate the purposive sampling of participants, meetings have been held with the supervisors. The supervisors made up of a business developer at MH and a logistician at SU. In agreement with the supervisors, week 17 was considered as an appropriate and representative week and was therefore chosen to be the week for shadowing. Together with the supervisors, it was also decided which of the RNs and NAs that should be shadowed, and during which shifts. To fulfil the study's purpose and to obtain a broad perspective, a range of participants were followed during different types of shifts. Relevant shifts in this study are mainly the patient-oriented shifts and are the same as the logisticians at SU used in their internal report. In total, three NAs and ten RNs were followed during five

days, through a total of 19 shifts. A normal workday contains two shifts, one in the morning and one after lunch. 15 of the shifts were patient-oriented RN shifts, three were patient-oriented NA shifts and one shift was intended for work with the case management system.

3.4 Evaluation of method

Critique commonly directed towards the qualitative research method often mentions its impressionistic and subjective approach (Bryman & Bell, 2011). The researcher in qualitative findings is the main instrument in order to collect data, and could therefore have an impact on the reliability of the findings. What the researcher hears, notes and concentrates on influences the result of the study. Furthermore, the respondent's answers and behaviour are likely to be affected by the characteristics of the researchers (ibid).

In order to minimise potential method bias, distinct scopes of what to focus on were developed before the observations. This was done both with and without the supervisors. Between the shifts, reconciliations were made between the researchers to ensure that the method worked as intended. It is of high importance to address potential disadvantages of the shadowing methodology. If shadowing techniques are applied incorrectly or inappropriately, participants may act differently with the purpose of concealing valuable information from the "shadower". This may lead to biased information and results without relevance. In order to affect the followed respondents as little as possible, the respondents were informed about the purpose of the study. Transparency between researchers and respondents was favourable, as the goal of the study was to understand the issues faced during a work shift rather than evaluating the performance of individual nurses. As a result, the aligned interests of all parties were clearly communicated. Another possible result of the shadowing methodology is that the nurses could feel distracted. Therefore, a neutral approach was considered appropriate, since this minimises the effect on the participant's ability to perform their work.

For the researchers, one disadvantage of using observation as method is its time consuming attribute (Kylén, 2004). One week of shadowing was considered optimal given the study's time frame. In order to further validate the findings of the observations, additional shadowing time could be beneficial. Statistical data compiled from this report is not intended to demonstrate overall utilisation rates, nor is it meant to give concrete advice on planning optimisation. Statistical data and insights collected from the observations should instead be seen as indications on how the ward's production could possibly be planned differently, given the resources necessary for more accurate statistical measurement.

Qualitative research also has issues in producing generalisable results. Through observations conducted with a small number of participants in a certain organisation, it is impossible to know how the findings of the research can be applied to other settings (Bryman & Bell, 2011). This study's intention is not to draw any generalisations or conclusions of how it works at the ward every week. It is rather intended to provide data and helpful information of how it can work at the ward a specific week.

In order to verify the practical relevance of the research for the studied organisation, frequent meetings were held with the supervisors. By confirming that the focus of the thesis provided results useful in their respective fields, it was possible to assure that the research remained on the right track throughout the process. After finalising the empirical findings and the analysis, a presentation was held for the whole management team at the department, where input from the different managers validated the accuracy of the observations and the relevance of the analysis.

4. Empirical Findings

Using the method described in the previous section, it was possible to identify, study, and classify the NAs' and RNs' daily activities. Furthermore, the duration of appointments and other activities, and the collaboration between different groups of employees could be observed. This gave an understanding of what the "non-scheduled work" actually was, and an insight in the various problems occurring on a daily basis.

4.1 Time Allocated to Different Activities

The ward's caregivers were divided into different teams, where each team had its own type of patient groups and appointments. Some equipment was "team specific" and some equipment was shared between different teams. Common to all teams was the scheduling, where each workday was divided into two shifts: one before lunch and one after. All teams were working in the same part of the hospital, and some teams shared rooms with each other. During the observation week, about one in ten of the RNs' shifts were intended for booked patient visits. The other scheduled shifts contained a variety of responsibilities, some of which were patient-oriented and some of which were non patient-oriented. These responsibilities could for instance be being available at the emergency ward, general administration, acting replacement resource at MH or at other SU hospital, handling referrals, being part of research and development projects, education, and working with the case management system.

By clocking the time required for various work activities, a study of how the time was allocated during the week of the observation could be made. The activities were divided into four different categories, shown in table 1.

Table 2
This study's definition of nursing activity categories

Patient time: appointment preparations, time spent on appointments, journal registrations, emergency calls and assisting colleagues with patients.
Case management system and general administration: handling case management system errands, waiting list administration, patient bookings, registration of diagnoses, assortment of referrals, work schedules and other general administration.
Breaks: scheduled breaks before and after lunch.
Other activities: staff meetings, personal activities, non-productive time, AN activities such as preparing rooms and being available at emergency room and other general activities.

As seen in table 2, the study shows that during the 15 observed patient-oriented RN-shifts, more than half of the RNs' time was dedicated to patient time. Nearly a quarter of the RNs nursing time were spent on the case management system and general administration. The total time spent on breaks (lunch excluded) and other activities was almost equal. During the three observed patient-oriented NA shifts, the figures differed compared to the RN shifts. The biggest observed difference between RNs and NAs was the time allocated to patient time and other activities.

Table 3
Percentage of nursing time spent on categories developed in this study

Activity	Registered nurses (%)	Nursing assistants (%)
Patient time	58	37
Case management system and general administration	26	22
Other activities	9	34
Breaks	7	7

In section 4.2 – 4.4, reasons to the unsatisfactory nurse utilisation rate during the observed patient-oriented shifts are described.

4.2 Administrative Work

The most apparent reason to why RNs cannot fully allocate their patient-oriented shifts to patient appointments is the different types of administrative tasks. This finding is not only based on the observations as it can also be verified by all caregiving employees at the ward. During discussions with several RNs, the administrative tasks were highlighted as time consuming, and as an important stress factor. Many hours are spent in front of the computer on non-nursing activities. Some of these tasks do not necessarily require RN competence, but are for different reasons their responsibility. As a result of administrative work, some RNs feel that they are not as patient-oriented as they could be.

Administrative activities at the observed ward involve a broad spectrum of different tasks and are managed by the RNs during, in-between and after patient visits. During patient-oriented shifts, administration amounts to 26 % of the RNs work. A large proportion of the total shifts

are also intended for administrative tasks only. The most frequently managed administrative tasks by the RNs during the patient-oriented shifts were, in no particular order, administrative errands received from the case management system, calls to patients for general bookings, booking of interpreters, reading medical records, handling referrals, registering and diagnoses. These observed administrative tasks have a major impact on the caregiving capacity and are, as one RN expressed it, formed as a pitfall. The more patients they serve, the more administrative work they need to deal with. The more administration that needs to be dealt with, the more prevented they are from serving patients.

4.2.1 Difficult administration

The RNs take care of a broad range of administrative tasks. Notably, some administrative tasks require a certain level of medical knowledge and proficiency. In these cases, the RNs provided professional care and utilised their professional skill to a high degree. For instance, dealing with some tasks related to referrals, as well as errands involving patient counselling in the case management system, required RN-level competence. Common for these responsibilities is that they involve some kind of medical assessment.

4.2.2 Easy administration

When the RNs were booking interpreters, scheduling and cancelling patient appointments, and registering diagnoses and referrals, part of their professional patient care time was spent on simple activities similar to those typically carried out by administrative clerks. Therefore, this type of administrative tasks can be considered easy administration as they do not require RN-level expertise. From individual discussions with some of the RNs, there were differing opinions regarding whether or not easy administration really had to be managed by the RNs.

4.2.3 Non-Standardised Routines

The teams, but also individual RNs, used different approaches regarding delegation of easier administration. One team routinely delegated waiting list administration to clerks, while one observed RN in another team politely knocked on an NAs door and asked for help with urgent patient bookings. Other RNs did not even delegate easy administrative tasks. A clear distinction in the working methods was observed, and there was a lack of standardised delegation routines of easier administration, as different teams had different routines.

Another identified occurrence connected to the administrative activities was the time allocated for these tasks. As mentioned before, administrative activities were managed during different occasions. When an RN had spare time between two patient visits, for instance because of a

time slot being blocked by a doctor or due to a cancelled appointment, the RN sometimes handled an errand in the case management system. And when the RN was scheduled for a shift with the case management system, the RN could sometimes combine the time allocated for case management system with other administrative activities. It was therefore difficult to track how much time that was allocated for administration in practice. A lack of continuity and clarity in the planning of the administrative activities created uncertainty throughout the shifts.

4.3 The Case Management System

According to the findings of the observational study, working with the case management system is a time consuming and recurring part of the RNs day-to-day work. The case management system is a tool for patient service, where patients who need to get in contact with RNs at the department are placed in a queue. Patients who want to reschedule, cancel or book an appointment, or are in need of RN counselling, first have to call the central telephone exchange "Kontaktpunkten", from where the errand is directed to the case management system at the Department of Ophthalmology. Patients mediated to the Department of Ophthalmology are, based on their need, directed to one of the teams' queues. Each team is then responsible for handling the errands placed in the queue. This responsibility was usually divided among the different RNs of the team.

The complexity of the errands varied from case to case in the observations. Administrative errands, such as cancellations, rescheduling, and bookings of appointments were sometimes fairly simple. The counselling errands sometimes required additional information as well as input from doctors, i.e. these were at times more difficult. According to the RNs, the time required for all errands was on average 20 minutes. However, this time varied between 5 and 30 minutes. This estimate can be somewhat confirmed by the observations, although one of the observed RNs needed 45 minutes per errand during an afternoon shift mainly dedicated to working with the case management system. This is a seemingly remarkable deviation from the time required by the other RNs in the study. Some mean that the efficiency differs from RN to RN, and that experienced RNs are able to handle the errands at a higher pace. Sometimes the RN would have to read through existing information about the errand before calling, but was then unable to get in touch with the patient, as the patient was not available at the specific time.

4.4 Difficulties in Planning

The ultimate goal when planning patient visits is to achieve the highest possible level of patient throughput given a certain level of service and treatment quality. However, this goal is complicated which can be confirmed by the observations. Several different resources had to be considered and coordinated when scheduling the production. In some cases, patient visits required availability of an RN as well as a doctor, and a room equipped with the right set of apparatus. The RN and the doctor in some cases also needed different amounts of time to fulfil their share of the work and to complete their administrative duties entailed by the patient visit. The time required for the visit and the urgency of the patient's needs is also considered. Furthermore, a certain amount of variability, uncertainty, and flexibility needs to be incorporated into the production plans. In several instances, these factors make precise optimisation of production planning especially complicated and bring about different kinds of inefficiencies.

Other difficulties in planning, observed in the study, are when patient visits of the same kind vary in time depending on the patient's language proficiency and age as well as the complexity of the treatment or medical assessment. The length of a certain type of patient visit may be estimated to e.g. 30 minutes, whereas the actual time required often varied between 10 and 50 minutes. This often results in either over- or underutilisation, and sometimes also in frustration from patients waiting in the waiting rooms for too long. If the first patient visit ends up taking more time than what was planned for, the rest of the visits of the shift may be delayed. During the observational study, one shift started with three consecutive shifts being unexpectedly time consuming. Besides from causing long waiting times for the patients, this also resulted in the doctor being left idle as she was waiting for the nurse to finish the first share of the appointments before sending them on. This variability in patient visit time is accounted for in the planning, resulting in a deliberate scheduled underutilisation.

Oftentimes, patient visits are cancelled, causing a need for rescheduling. Therefore, the benefits of using one standardised visit time approximation is considered to outweigh the resulting loss in scheduling precision, as rescheduling is fairly simple when all visits are given the same scheduled time.

The doctors have the right to "block" a certain share of their shift when they think that the actual required time for appointments might exceed the scheduled time. Blocking times is common for doctors receiving their specialist training at the hospital, since they need more

time for each patient during their learning period. During one of the shifts observed in the study, a RN was working together with a doctor who was going through his specialist training and who needed a RN to assist him throughout the shift. The normal pace of work during a shift of this kind would be seeing five to six patients, but since the ST-doctor needed additional time for the appointments, he had decided to block two time slots. For the RN assisting him in his work, this resulted in under-utilisation during the shift as her task was to assist the ST-doctor. Since the current system assigns a certain type of shift to the RN, it is not possible for the RN to schedule other kinds of appointments than those of the specific shift. This means that the RN in this case was left with excess capacity. Some teams had been working with the same doctors for a relatively long period of time, and had learned to coordinate their efforts effectively as well as to minimise the impacts of doctor unavailability. Other teams were often working with new doctors undergoing specialist training, which sometimes results in many blocked time slots, also affecting the nurse's productivity.

Another issue leading to underutilisation during certain types of shifts was patients not showing up for their scheduled appointment. In one instance this resulted in three out of six planned appointments being cancelled without notice. Since the patients cancelled without notifying the hospital, the RN still had to prepare for the appointments. When the RN was ready to receive the patient and the patient had not yet showed up, the RN had no other option but to wait. This made it difficult to focus on other tasks, since the RN still had to be prepared in case the patient would end up arriving.

For the NAs, some of the shifts are planned with deliberate gaps in between the appointments since the NAs need to be available to assist doctors in the emergency ward. The NA resources required for assistance at the emergency ward are highly irregular, meaning that they at some points are understaffed, but that they sometimes spend periods of time completely idle. The NAs also had difficulties using this spare time in a productive way since they don't have access to the facilities necessary for handling administrative work. If an NA wanted to do paper work, they would sometimes have to search for available computers in rooms that were often already busy because of undergoing patient treatments.

5. Analysis

5.1 Interpretation of Empirical Findings

According to the findings of the observational study, the main issues related to low utilisation of care producing staff are the high share of tasks not directly related to caregiving, and the difficulties in planning and optimising the production. In this section, these issues are elaborated upon.

5.1.1 Planning and Uncertainty

As seen in the observational study, the production of healthcare service is dependent on several different factors, requiring coordination on several levels. Not only do the different production factors incorporate different sources of uncertainty, such as varying availability of equipment, personnel and facilities, but these must also be coordinated with the scheduling of patients. One aspect of service production making it different from manufacturing of goods is the fact that the production and consumption of the output occur simultaneously. Part of the difficulties in planning arises due to uncertainties on the "consumption side" of the process. These uncertainties occur as there is a risk that the scheduled patient will show up late or not at all, or that the patient will require more time because of age, language capabilities, medical condition, or other unpredictable events incurring when dealing with people. Furthermore, additional flexibility is required as the urgency of different appointments varies. This means that the schedule needs to include additional space in case a patient requires care with short notice. One example highlighting this issue is the fact that the NAs need to be available for assistance at the emergency ward, which restrains their ability to support the RNs in fulfilling their work. All in all, these factors create an environment of uncertainty that in some ways has given flexibility and room for ad hoc solutions priority over planning.

Some of the difficulties and obstacles preventing healthcare organisations from applying long and short term production planning, similar to the planning and scheduling methods often used in industry are described by Plantin and Johansson (2012). In their study of Skaraborg Hospital's surgery department in Skövde, the fact that much of the department's production capacity was determined by the varying availability of doctors led to difficulties in achieving balanced production flows and optimised utilisation of other personnel resources. At the Department of Ophthalmology at MH, a similar situation could be observed as the varying capability of different doctors with different competence levels had a negative impact on production continuity and on the workload assigned to the RNs. Although SU has the outspoken goal of using production planning to set the production pace, the method has not

yet been successfully implemented. The overall approach of letting capacity set the pace of production, rather than adjusting capacity to estimates of demand to achieve the desired level of production is a similarity between the two cases.

In the study made by Plantin and Johansson (2012), a few reasons to why production planning has not been widely embraced in healthcare are suggested. One reason is that basic values and priorities may differ from those of private industry. For instance "caring", often described with characteristics such as physical and emotional presence, anticipating needs, and fostering relationships, is central to nursing. According to some of the nurses at MH, the term production is not commonly used among caregiving employees. A possible explanation to why may be that "production" is not considered useful in accounting for the full value of the caring aspect of nursing. Therefore, the caregiving staff may feel sceptical towards the applicability of methods borrowed from industry.

5.1.2 Administrative Issues

A wide range of administrative tasks, sometimes carried out more or less simultaneously, are woven into the daily work of the RNs. The different administrative activities often fill up the gaps scheduled between appointments or the extra time given when appointments are finished earlier than expected. Besides the fact that the administrative work is time consuming, it also makes it difficult to optimise the scheduling of appointments, since time has to be assigned to "administrative gaps". Furthermore, the continuous management of small administrative errands possibly functions as justification for not fitting in more appointments during the shift. Some RNs seemed to consider efforts to fit in more appointments during the shifts meaningless, as they already use all their spare time dealing with administration. The current way of dealing with small administrative tasks throughout the day possibly causes efficiency losses, as switching between different tasks often requires additional time for adjusting to the different contexts.

5.2 Analysis of Operations Management Applications

If a larger share of the RNs' time could be spent serving patients, the number of appointments per day could increase for several patient groups. Therefore, the caregiving capacity of the RNs could be considered a production bottleneck. One factor limiting the caregiving capacity is the administrative work assigned to the RNs. The findings of the observational study shows that many different administrative tasks and case management system errands may be handled by overqualified professionals, and that there may be inefficiencies in the way these tasks are

carried out. The applications of Operations Management presented in this section are meant as suggestions on how to address both of those issues.

5.2.1 Task Shifting of Administration

The administrative burden assigned RNs at the ward is, as previously stated, an important reason to the long patient waiting times. In order to decrease the ward's long queues by increasing the caregiving capacity of RNs, task shifting may be an option.

Applying Task Shifting

From the observational study, a rough idea of which "shiftable" tasks RNs are undertaking is given. Obtaining this information is a necessary first step when determining whether or not task shifting is applicable in a specific context (Duffield et al., 2008). There are many similarities between the studied ward and the settings of other task shifting implementations, suggesting that task shifting may be a feasible option for the ward. For instance, a large share of the total nursing time is allocated to non-nursing activities. A key reason to why this is the case is the administrational work assigned to the RNs. Although the hospital environment may vary between countries, Morris et al. (2009) describe a similar situation where tasks below the competence level of different professionals restrained them from maximising the utility of their expertise.

The administrative work takes place in both the patient-oriented shifts, but also during shifts intended for administration only. Lundgren and Segesten (2001) describe similar findings where patient administration and general management could be reduced in favour of caregiving time. Based on the observation, the administration at the ward can be divided into two categories: easy administration and difficult administration. This also supports the applicability of task shifting, since easy administration is easier to shift to other professions with less training. In their report, Lundgren and Segesten (2001) suggest that more paper work should be managed by supporting staff. A shift of easy administration from RNs to less trained professionals may also be possible at the studied ward at MH. Lastly, if these easy administrative tasks would be shifted, other professionals with the skills necessary for taking on the additional work, e.g. NAs as well as administrative and medical clerks are available. Furthermore, these employees are not as scarce on the labour market as the RNs, meaning that MH could employ more people working with easy administration in order to let the RNs focus on appointments.

The tasks considered as easy administration in table 3 are the tasks mainly applicable for task shifting in this context. Some of the easy administrative tasks are suggested by the RNs, while some administrative tasks were found easy during the observation. The professionals involved then confirmed the low level of complexity.

Table 4
This study's distinction of easy and difficult administration

Easy administration: booking of interpreters, some patient booking, rescheduling and contact with patients from patient list, registration of diagnoses, receiving delivery of medical inventory and other easy administration.
Difficult administration: referrals, medical advise in the case management system, writing medical record and other difficult administration.

Results of Task Shifting

If some of the administrative work could be moved from the RNs' set of responsibilities, a larger share of their time could be spent on caregiving activities. This would increase their caregiving capacity, resulting in a higher patient throughput at the ward. The productivity gains could be achieved by alleviating administrative tasks from the RNs during patient-oriented shifts as well as during administrative shifts. Reducing the RNs' share of administrative work during patient-oriented shifts would result in more time for patient appointments. Similarly, having other professionals managing a larger share of the work during shifts intended for administrative work only, would enable an increase in the total amount of patient-oriented shifts. Taken together, these efforts would contribute to shortening the waiting time for the medical procedures provided at the ward.

5.2.2 Planning Administrative Work Using Queuing Theory
Background

Based on the observations and discussions with RNs at the ward, the current routines for case management system work lacks standardisation and structural coordination. Various RNs are today involved in working with the case management system, meaning that it is carried out with little continuity and across many shifts. This results in difficulties in optimising the schedule as well as in increased downtime and efficiency losses. Insufficient knowledge about how much time should be allocated to case management work also results in lower patient care utilisation among RNs as patients bookings are side-lined in favour of work in the case management system, although it is not known if this is needed or not.

The logic typically used in PPC is especially useful in approaching this problem. By first using historical data to prognosticate the weekly and daily arrivals of errands into the system, the case management system can be staffed given the required level of output. It is then also possible to figure out the most efficient way to achieve the necessary pace of production. The transition to a more demand based approach to resource allocation has proved to yield great results in the report written by Plantin and Johansson (2012), and is also a prioritised albeit not yet fully embraced method at the department.

As shown by previous studies, queuing theory is a useful tool when finding the optimal staffing level, given a certain service level, or production goal (Agnihothri & Taylor, 1992; Palvannan & Teow, 2012). By applying queuing theory, estimations of the time required for handling the incoming errands can be made, and the connection between staffing level, queuing time, and staff utilisation rate can be evaluated. One potential solution would be letting a number of non-team bounded specialists handle all simpler case management system errands such as bookings, cancellations and rescheduling of appointments. This would mean that the work with the case management system is carried out in a more structured manner, involving a smaller number of employees. Optimally, less skilled proficiencies can be trained to handle these tasks.

The Variables of the Queuing Model

In order to apply a queuing model, input on arrival rate (λ), service time (μ) and number of servers (s) is needed. To validate the model, certain queue characteristics need to be studied such as serving order and limitations in queue length. It also has to be studied whether the process can be considered a "single phase system".

Arrival Rate (λ)

A study of all incoming errands related to booking, cancellation and rescheduling of appointments during four weeks gives an hourly average of 3,1 errands. According to the observed data in table 4, the arrival rate varies over the week as the number of arriving errands are higher in the beginning of the week, and typically reaches lower levels during Thursdays and Fridays. The arrivals are assumed to occur independently of each other.

Table 5
Non-counselling case management system errands mediated to the ward

	Monday	Tuesday	Wednesday	Thursday	Friday
Week 14	33	29	28	15	0
Week 15	0	26	24	16	21
Week 16	32	26	33	15	23
Week 17	31	29	23	23	16
Average Daily λ	32	27,50	27	17,25	20
Average Hourly λ	4	3,44	3,38	2,16	2,50

Service Time (μ)

According to the findings of the observational study, a reasonable estimation of the time needed to handle an errand is on average 20 minutes. This average applies to counselling as well as booking and scheduling errands. However, the time typically varies between 5 to 30 minutes. These figures are estimated together with RNs.

Number of Servers (s)

Due to the fact that a large share of the work is done "off schedule", attempts to estimate the available number of servers, i.e. nurses working with the case management system, have not been made. The modelling carried through in this section explores different levels of server capacity and its impact on other queue metrics.

Other Characteristics

Errands arriving to the queue system are mediated from a primary telephone line at SU to the Department of Ophthalmology at MH. The errands are then placed in line in the case management system, where they are handled in accordance with the FIFO-principle by the RNs at the department. The department has to accept new errands no matter how many patients that are already waiting in the queue. This means that the queue does not have an upper limit restricting its length. After the patient's issue has been dealt with, the errand leaves the system. As the examined part of the patient's interaction with the hospital contains only one process, it can be considered a single-phase system.

Applying Queuing Modelling

In order to find the required number of employees working full time with handling errands related to booking, cancelling and rescheduling appointments, the relation between λ, μ, s and queue length is examined. Given factors regarding the arrival rate, the service time, and the flexible number of servers an M/M/s queuing model is appropriate for approximating the

operating characteristics of this queue system. Since λ varies over the week, the analysis is made with different λ values: the overall average (3,1), the highest arrival rate of the week (4) and the lowest arrival rate of the week (2,2). The output tables from the queuing model analysis are given below.

If the hourly arrival rate (λ) of errands is 3,1, having only one server (i.e. one full time employee) will according to the queuing model result in an infinitely long waiting line. This happens when the number of servers multiplied with the service rate is lower than the hourly arrival rate, as the number of patients in the waiting line will increase in perpetuity. If on the other hand two servers would be assigned to handling errands in the case management system, the average waiting time would be approximately 0,12 hours, and the utilisation rate of these two servers would be around 38 %. These numbers indicate that the optimal staffing level would be having more than one but less than two servers working with managing bookings-, cancellations-, and rescheduling errands. In a scenario where arrivals into the system are as frequent as on Mondays, i.e. λ = 4, two servers still result in a low average waiting time (0,27 hours) and a utilisation rate of 67 %. If s = 1 when λ = 4, the queue will theoretically grow to infinity. According to the queuing model, the optimal level of staffing is also here between s=1 and s=2. The only scenario in which s=1 is possibly a sufficient staffing level is when λ = 2,2. S=1 would result in a utilisation rate at approximately 73 %, meaning that a possible optimal staffing level would be having less than one server. Since two servers result in a very low server utilisation during all considered scenarios, any staffing levels with more than two employees would result in even lower levels of server utilisation. However, if λ=5, two servers would still be a sufficient staffing level as this would result in a server utilisation of 0,83, and a waiting time of 1,09 hours. If the arrival rate would increase to λ = 6, a third server would be needed in order to manage the incoming errands since 2 servers would result in a theoretically infinite waiting time.

Table 6
Values of operating characteristics given different arrival rates and staffing levels

λ	s	Lq	Wq	ρ
4	1	∞	∞	n.a
	2	1,07	0,27	0,67
3,1	1	∞	∞	n.a
	2	0,38	0,12	0,52
2,2	1	2,02	0,92	0,73
	2	0,12	0,05	0,37

Results

Conclusively, applying the queuing model to the case management system shows that no more than two employees working full time with handling the specified errands is necessary in order to achieve reasonable waiting times during the four observed weeks. When the arrival rate reaches its weekly low, a sufficient staffing level is achieved by assigning one employee to the task. One possible setup would be having a single employee working full time, with assistance from another employee at times where the arrival rate is high. If the errands vary in complexity, having two employees with different levels of competence, where the more skilled employee is responsible for handling only the errands that require medical assessments, could be a working solution. If the employee with the higher level of competence, e.g. a nurse, is responsible for managing the more complex errands only, such a solution would make sure that necessary competence is available when required, but that precious nursing time is not spent on simple work.

Potential gains from a redesign and queue model are many. Firstly, the production planning of the case management system can be enhanced. Less activities coordinated among fewer employees simplifies the work and enables optimisation. With access to estimations of how much time that should be allocated to case management system, the time scheduled will be done so more precisely. Observed in the empirical findings, today many RNs manage the case management system spread out on many occasions in an unstructured way making it difficult to optimise the work with it. Secondly, a smaller number of employees taking care of the case management system could possibly decrease the total downtime. They will also attain specialist knowledge by a steeper learning curve. Thirdly, if less trained professions can be trained for these tasks, a work shift may be feasible and the RNs time can be better utilised. Applying a queue model simplifies the process of deciding how many people that is needed for a work shift. Lastly, less tasks managed by RNs may decrease the today's high level of stress and uncertainty at the ward.

6. Conclusions

6.1 Concluding the Research Questions

This thesis aims to investigate and analyse issues in utilisation of personnel resources in the production of healthcare at a specific outpatient ward. The thesis also intends to suggest and to analyse possible actions of improvement using theory from the fields of management and industrial management. In order to address the purpose of this study, the research questions will be revisited and concisely answered.

1. Which factors in the daily work of registered nurses and nursing assistants lower their capacity for caregiving activities?

According to the empirical findings of this research, there are three main factors contributing to an unsatisfactory caregiving capacity for the RNs. Firstly, the high share of administrative work carried out throughout the shifts reduces the time that the caregiving employees can spend on patient appointments. Secondly, the handling of errands going through the case management system shifts capacity from assessing and treating patients at the ward, to managing administrative errands and to provide patient counselling over the phone. Thirdly, the difficulties in planning the appointments in an optimal way create inefficiencies that lower productivity. The difficulties in planning affect the RNs as well as the NAs. In terms of PPC, these difficulties occur in the lower levels of the planning hierarchy.

For the managers working with developing the ward, these findings provide some understanding of issues that were previously only suspicions, or in some cases completely unknown. With a better understanding of factors lowering the personnel utilisation rate at the ward, their ability to fully address these issues is improved.

2. How can operation management methods be applied in order to increase the capacity for caregiving activities among the registered nurses?

Previous research shows that there are many possible applications of operations management in healthcare. Considering the context of this study, two examples of practical measures are especially interesting when approaching the issues lowering the caregiving capacity of the RNs. Firstly, redesigning the work by "task shifting" certain responsibilities has the potential of giving the RNs more time for caregiving activities. Secondly, applying calculations from

the field of queuing theory is useful in issues related to staffing, and could enable optimisation of the work carried out through the case management system. This could potentially lead to a higher share of RN capacity being used for patient appointments.

This study contributes to the field of operations management by bridging a gap between theory and practice. Although operations management theory is useful in various settings, factors specific for certain contexts may affect the applicability of the different methods. The research presented in this study describes issues occurring at an outpatient ward providing medical procedures for planned patients, and describes how the methods of queuing modelling and task shifting can be useful in addressing the observed issues. It also describes problems related to PPC. In doing so, it enriches existing theoretical frameworks, and enables future research related to healthcare productivity to further build upon these findings.

6.2 Suggestions Regarding Further Research

Many important questions have remained overlooked throughout this research project. One of the most important issues that have been beyond the scope of the study is the communication between management and caregiving personnel at the ward. Many of the problems observed at MH and in other studies require coordination between different organisational levels to be solved. Thus, communication throughout the organisation is a potential key issue when working towards improved productivity. This is a field in which contributions could be of great practical significance for healthcare organisations similar to the ward observed in this study. Further studies in management on the communicational aspects of improvement projects in healthcare are therefore encouraged by the authors of this paper. Another issue, that has been given high priority by the management at the ward, and that may be of academic relevance is the ways in which innovation and improvement efforts from the caregiving personnel is leveraged and encouraged. Studies of innovation management could in this context involve both organisational as well as production innovation. Initiatives in this area have already been taken, and research in the field could involve evaluation of the current system.

Since production planning is an area of interest for SU, further research about the production planning and control processes could be based on a solid foundation of current documentation. The emphasis of this study has been on the lower levels of the production planning hierarchy, where there are many issues to elaborate upon. Deepened research on the applicability and the practical implications of queuing modelling systems as well as task shifting could be great ways of adding to the findings of this study.

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