Effects of machine sharing in hospitals on operational efficiency and service quality – A case study in the region Twente, Netherlands

Author: Rob Schildkamp
s2915669
University of Twente
P.O. Box 217, 7500AE Enschede
The Netherlands

ABSTRACT

Hospitals increasingly face internal and external pressures that affect their performance as service-providing organizations, which may affect their priorities in decision-making processes. One way to deal with these pressures, is by sharing machinery between departments. However, there is lack of research on intra-organizational machine sharing within organizations and in the service sector, especially in health care. This research aims to contribute theoretically by identifying potential impacts of sharing in contrast to owning medical devices on operational efficiency and quality of service delivered in hospitals, to fill this literature gap. This is done by conducting a case study of a hospital in the region Twente in the Netherlands. It will face a renovation project that threatens their current sharing system, and requires a choice to be made between owning or sharing an ultrasound device between departments. In this hospital, twelve in-depth interviews were done with a heterogeneous, multi-disciplinary sample to gather subjective experiences on the processes related to the usage of the ultrasound device. The interview transcripts were analyzed through a thematic analysis, supported by a quantitative analysis of time measurements with financials and research data. This methodology resulted in a detailed and simplified overview, showing how the operational efficiency and quality of service are directly impacted through the capacity and costs related to sharing and owning a device. Furthermore, the route to transfer patients is an intermediary variable that influences both the employees and patients, which affects the operational efficiency and quality of service. This research also aims to contribute to practice by supporting departments in hospitals who are facing a decision of either sharing or owning medical devices. The results can help better understand the relationships between factors inside a hospital, and identify underlying factors that can be changed to improve the operational efficiency and quality of service.

Graduation Committee members:

Dr. Barbara Kump
Dr. Lara Carminati

Keywords

machine-sharing, services-industry, hospital, case study, interviews, operational efficiency, quality of service

1. INTRODUCTION

The healthcare sector is one of the most important sectors in the service industry (Hod et al., 2016). Yet, the pressures on hospitals and their employees increase. As a result, the effect(s) on (service) quality are not always one of the top priorities of the decision makers, leading to diminishing efficiency and quality of care delivered (Hod et al., 2016). Neglecting the customer satisfaction and service quality can "be inviting a loss of patients" (Amin & Zahora Nasharuddin, 2013, p.238, as cited in Andaleeb, 1998; Padma et al., 2010).

According to Nederlandse Vereniging van Ziekenhuizen (2023), the hospitals in the Netherlands were heading towards a financial deficit of €300 to €420 million in 2023 and 2024, due to the increasing costs of staff, energy and procurement. Furthermore, according to RIVM (2020), the health care expenditures will increase with about 2,8% every year until 2060. Hospitals have to make financial cutbacks to lower their costs, which is considered socially irresponsible given the increase of demand for care and staff shortages (Nederlandse Vereniging van Ziekenhuizen, 2023). These staff shortages and high costs might lead to care that is less efficient, considering how operational efficiency is defined in hospitals (Yaduvanshi and Sharma, 2017). See chapter 2.1.

A phenomenon that has proven to be able to lower costs and increase efficiency, is the sharing of machinery (Puschmann & Alt, 2016). Research has been done on how machine-sharing is applied in the agricultural industry, where farmers share their machines with each other, to benefit from e.g. less idle time of a machine (not being used), and higher product yields (Larsén, 2010). This is an example of inter-organizational machine sharing. Another sector in which machine-sharing is used and researched, is that of cellular manufacturing organizations (Benjaafar, 1995), which is an example of intra-organizational sharing. The organizations in both sectors thus are manufacturing organizations, resulting in literature focused on product-delivering organizations, not service-providers. Moreover, the literature of intra-organizational machine sharing is limited to that of the cellular manufacturing organizations.

There is very little research done on machine sharing in the healthcare sector, hospitals in specific. Research on machine sharing vs a non-sharing system is especially an important topic to research since hospitals, for example in the Netherlands, experience increasing pressure on their (operational) performance due to (amongst others) an increasing demand for healthcare, insufficient growth of healthcare staff, high absenteeism (Dantuma, 2024), and an overburdened workforce of nurses in hospitals (European Commission, 2021). Therefore hospitals might benefit from the advantages of machine sharing.

However, the sharing of resources, such as wheelchairs and crutches, between patients in the health care sector has gotten more coverage in previous research, but has been limited to patients and the resources shared between them (Xue & Zhang, 2023). There has been research on machine sharing in the healthcare sector, namely that of Bertnum et al. (2023), but this is limited to medical laboratories.

Therefore, the research gap identified for this research is one of multiple aspects. Research on machine sharing has focused on manufacturing organizations, resulting in almost no research on machine sharing in the context of service-providing organizations, such as hospitals. Research on intra-organizational machine sharing has mainly focused on manufacturing organizations, leading to limited information about other industries. Lastly, the research on sharing in hospitals has mainly focused on sharing equipment between patients, resulting in lack of research on machine sharing across departments in hospitals. Thus this research aims to fil the existing gap in the literature by answering the following research question:

What are potential impacts on operational efficiency and patient care quality by sharing in contrast to owning medical devices within a hospital?

This will be done by conducting interviews, complemented by time measurements and research data, to research the effects of intra-organizational machine sharing on operational efficiency and quality of service delivered. To contrast this effect, it will be compared to a situation where departments own their own machine. By answering the research question, this thesis makes three main theoretical contributions to the literature on machine sharing. Firstly it provides nuanced results on the potential effects of machine sharing and owning on operational efficiency and quality of service. Secondly, it provides research on machine sharing between departments. And lastly, it explores machine sharing in a service providing organization, specifically the health care sector. It also contributes to practice in four ways. First, it provides an overview of interrelated factors influencing operational efficiency and quality of service for decision-making processes. Secondly, it helps to understand the relationships between these factors. Thirdly, it highlights the importance of the intangible factors that cannot be easily expressed in financials. Lastly, the methodology is an example on how quality and efficiency can be held as top priorities, while also involving employees and financial data.

2. THEORETICAL BACKGROUND

2.1 Pressures on hospitals

2.1.1 Workload and efficiency

According to Hod et al. (2016, p.1) "the world has changed from an industrial world to a service-oriented commercial world", with the healthcare sector being one of the top growing ones in the service industry. Hospitals are one of the cornerstones of society, as 2.921.495 people in the Netherlands were hospitalized in 2022 (RIVM, 2024). Even though this number is on a decreasing trend, the pressure on hospitals increases and affects its decision-making processes. According to Centraal Bureau voor de Statistiek (2022), this is partly due to the majority of employees experiencing a too high workload. An average 50% of the employees in the Dutch healthcare system feel that their workload is (way) too high, as per the second quarter of 2022 (Centraal Bureau voor de Statistiek, 2022). In the hospitals, the perceived workload is slightly higher, namely 50.4% (Centraal Bureau voor de Statistiek, 2022). According to Ministerie van Volksgezondheid, Welzijn en Sport (2025), the demand for staff in healthcare will grow with 22% by the year 2034, and the supply of staff will only grow with 8%, leading to a labour shortage of 288.600 by 2034. Thus the workload of these employees will increase even further. This will affect the operational efficiency of hospitals, since in a hospital it is defined as "rapid access to care, minimum waiting time while at the same time delivering defect free quality care at the minimum cost" (Yaduvanshi and Sharma, 2017, p.203).

According to Bogyo (2024), the workload affects three main actors: the *employees*, the *patients* and the *health care institutions* themselves. Due to the undercapacity, *employees* are more likely to have more burn-outs and absenteeism, are less motivated with less job-satisfaction, and are more prone to make mistakes. In turn, the *patients* are affected as employees have less time and attention for the patients. Thus operational efficiency is affected through less rapid access to care and less defect free quality of care delivered. According to (Verest et al., 2019) the employees confirm this, as 24.8% are (very) unsatisfied with the time they have to deliver good care to their clients, 28.6% are (very) unsatisfied with the individual care they can offer their clients, and 31.5% are (very) unsatisfied with the psychosocial guidance they can offer their clients. Lastly, it affects the *health care institutions* (like hospitals) themselves as it leads to higher costs (for example by replacing employees and their recovery), thus inefficient as operational efficiency requires minimum costs. Additionally, they suffer reputation damage, and as employees are overworked, processes slow down, and performance and operational efficiency lowers (Bogyo, 2024). The latter is damaged since it leads to less rapid delivery of care, more waiting time for patients and more costs (Yaduvanshi and Sharma, 2017). In turn, the quality of patient care lowers (Verest et al., 2019).

2.1.2 Quality of service

Decisions regarding efficiency in the resource intensive nature of hospitals have been minimally based on quality consideration (Hod et al., 2016). Quality in hospitals has two elements: "clinical (technical) quality" (Hod et al., 2016, p.1), and "service (functional) quality" (Hod et al., 2016, p.1). The former is defined as "the ways in which inputs from the health system are transformed into health outcomes" (Hanefeld et al., 2017, p.368). The latter is defined as "the characteristics that shape the experience of care beyond technical competence" (Kenagy et al., 1999, p.661). The few researches that were oriented on the quality of operations in hospitals, focused on clinical quality, not service quality (Hod et al., 2016). The latter can be measured by what patients perceive (Hod et al., 2016), and as identified above, by the employees' perception (Centraal Bureau voor de Statistiek, 2022).

According to Amin and Zahora Nasharuddin (2013, as cited in Eleuch, 2011) patients generally do not have the knowledge to judge the technical quality of care delivered, such as the skills of cardiologists, but put more emphasis on the functional quality, which is defined through their interaction with personnel (doctors, nurse, and staff). This defines the trust a patient has in the medical capabilities of the hospital. According to Amin and Zahora (2013), several models have been developed to capture hospital service quality, but "admission, medical service, overall service, discharge and social responsibility" (p.247) are the most fitting dimensions. Overall service is the most prominent determinant of hospital service quality, which entails (amongst others) that services are delivered when promised (Amin & Zahora, 2013). Thus, operational efficiency influences the quality of care delivered.

The paragraphs above shows that the increasing pressures on the healthcare sector negatively affect the employees, which undermines the operational efficiency of the healthcare institutions and diminishes the quality delivered to patients. Thus operational efficiency is an increasingly important factor to account for in decision-making processes to ensure quality of care is considered.

2.2 Machine sharing

2.2.1 Machine sharing in various industries

In the agricultural and forestry industries, "machine-sharing arrangements" (Larsén, 2010, p.497) are made to drive costs down and increase efficiency (Puschmann & Alt, 2016). These arrangements reduce capital costs, make self-financing easier, increase product yields, product prices and specialization (Larsén, 2010). The firms operating in partnerships, showed a higher average efficiency than non-partnership farms, which is strengthened by farms being more developed, i.e. being able to buy machinery of higher quality (Larsén, 2010). However, this arrangement also comes with disadvantages, such as the principal-agent problem (Larsén, 2010, p.498). There has been research on the (financial) effects of machine-sharing amongst farmers in Canada, which showed that overall, the co-operating firms faced fewer costs than their individual counterparts, even though the total costs of the co-operative exceeded the costs of the individual farmer (Harris & Fulton, 2000).

Machine sharing in the agricultural sector regards inter-organizational activities. Intra-organizational sharing has been mainly researched in the area of (traditional) cellular manufacturing systems, where the shopfloor is divided into different cells (Benjaafar, 1995). There "the transformed resources entering the operation are pre-selected … to move to one part of the operation (or cell) in which all transforming resources, to meet their immediate processing needs, are located" (Slack et al., 2022, p.224). Benjaafar (1995) researched the effect of a machine sharing system on performance measures, and Irani et al. (1993) researched the effect of machine sharing on intercell flow to simplify assigning machines to cells. There has been more extensive research on machine sharing in manufacturing organizations, like Blaettchen et al. (2020), Benjaafar (1996), and Sheikhzadeh et al. (1998).

2.2.2 Machine sharing in hospitals

The sharing of resources also affects the medical industry, where sharing medical equipment has potential health risks, identified as the Healthcare-Associated Infections (HAIs), which are "common, costly, yet largely preventable complication[s] impacting patients in healthcare settings globally" (Browne et al., 2023, p.1). The contrast between the research on manufacturing organizations and hospitals, is that the former been focusing on organizations producing goods, whereas in hospitals a service is delivered rather than a product being produced.

The shared-use of medical equipment ranges from e.g. wheelchairs and crutches to MRI devices and ultrasound scanners, which incorporates waste reduction (Xue & Zhang, 2023). The former two are a different type of medical equipment, in the sense that these are (also) used and shared by patients without supervision of medical staff, whereas the latter two are machines that medical staff use on patients, and can be shared between the medical staff itself. Research on sharing in the medical industry focused mainly on the effects of medical equipment being shared across patients. The effect of "resource sharing on medical laboratory performance" (Bertnum et al., 2023, p.515) has been researched because of the higher demand for healthcare service. However, this research was limited to the medical laboratories, yet was the only research that focused on machine sharing in the service industry (Bertnum et al., 2023). According to Xue & Zhang (2023) research has been done on medical equipment rental systems; inexpensive medical equipment on a fee-basis; portable equipment related routine cleaning; decision-making process to evaluate alternative equipment; privacy-preservation and on-demand consumption.

Thus, there is lack of research on the comparison between machine sharing arrangements and non-sharing systems in hospitals, and its effect on operational efficiency and quality of the service being delivered (patient care). Thus looking beyond the mere financial criteria that have been used in agricultural machine-sharing research, to find out the effects of owning versus sharing a machine. It is important to further investigate this to widen the knowledge on this phenomenon.

2.2.3 Effect on operational efficiency

Intra-organizational machine sharing between departments affects the allocation of resources. For example, less machines being used in a sharing system limits the autonomy each different actor has on the placement of the machine. When machines are used separately, more machines are in use, and could therefore be placed in closer proximity to the designated user. According to Yaduvanshi and Sharma (2017), a hospital in Virginia saved 11 million USD by applying the 5S's of Lean Six Sigma to limit the time that employees have to walk around and search for equipment. Therefore, the placement associated with machine sharing (or separate usage) concerns operational efficiency. The given definition namely incorporates the amount of waiting time and rapidness of care delivered, at minimum cost. Moreover, the increasing pressures on hospitals and its employees put extra pressure on the feasibility of machine sharing and therefore the quality of care delivered through operational efficiency.

3. METHODOLOGY

3.1 Methods

In this research, a case study is done with a hospital in the East of the Netherlands, in the region Twente. According to (Schoch, 2020, p.245), "a case-study is an in-depth investigation of a contemporary phenomenon within its real-life context". The case study is mainly qualitative, as in-depth interviews are conducted. The results are analysed with a thematic analysis through coding the transcripts. This is complemented by time measurements, financial, and machine usage data, thus also quantitative analysis.

3.2 Case

The hospital chosen for this case study is anonymized in this report. This hospital is chosen because it will face a renovation project in the near future, which will put stress on the shared used system for approximately four to five years. As per the status quo, two departments namely are sharing an ultrasound device. However, in the upcoming reorganization one of the departments (Coronary Care Unit (CCU) – 3West) will be relocated to a different side of the hospital, while the other department (Cardiologic Clinic - 3North) stays at their current location until their new location is built as well, which is expected to take four to five years. Then they will be in close proximity of each other again. However, bridging this period with one device will expectedly lead to problems for the current sharing system. If the ultrasound will be shared and positioned close to either department, then patients from the other department have to be transferred over a much longer distance to reach the machine. Appendix 8.1 shows a map of the hospital with the current and future transfer routes. The future route represents the route that has to be walked when the device is shared over the longer distance. This raises concerns and is expected to affect operational efficiency and the quality of care delivered to patients. This puts the hospital in a dilemma: continue or cancel the current sharing system (by purchasing an additional ultrasound device) to bridge these five years. This is where the limitations of existing literature and the arising problem at this hospital meet: what influence does sharing or owning a machine have on organizational efficiency, and quality of service delivered to the patients?

3.3 Data collection

For this case study, in-depth interviews were held with employees, since this type of interviewing is "used to gather data on the subjective experience of participants" (Rutledge & Hogg, 2020, p.1). They are often used by healthcare researchers (DiCicco-Bloom & Crabtree, 2006). Traditionally these are done one-on-one to observe both the verbal and nonverbal communication of the interviewee, while mimicking a conversational setting, to connect with and understand the interviewee (Rutledge & Hogg, 2020). The suggested approach of in depth-interviews as described by Boyce and Neale (2006) is used to structure the interviews.

Interviewees were identified through purposive sampling, since this allows to select a participant "because it illustrates some feature or process we are interested in" (Silverman, 2024, p.61). Firstly, the participant has to be working at either department or operate the ultrasound machine. Secondly, their day-to-day tasks are directly affected by the usage of the ultrasound device. Third, the final sample should include different job functions to gather a wide sample of the population. This represents a Maximum Variation Sampling (MVS) or heterogeneous sampling. Which allows "to look at a subject from all available angles, thereby achieving a greater understanding" (Etikan et al., 2016, p.3).

The aim was to conduct minimally ten interviews, as from eight interviews and more the additional information identified saturates (Brown, 2016, as cited in Griffin & Hauser, 1993), i.e. almost all of the identifiable topics are identified. A total of fourteen participants were contacted. Eventually, twelve interviews were conducted to increase the chances of saturation. One of these only could only cover the first nine questions due to time constraints. The sample was made up of Head of Units, cardiologists, nursing staff, ultrasound operators and a unit coordinator. The exact amount of each is not mentioned to ensure anonymity. As saturation was present, more interviews were not needed. These interviews are anticipatory on the reorganization that will take place at this hospital in a few years. The interviews were designed to get to know the experience of the participants and their personal opinions or preferences towards a new status quo. Therefore these interviews do not resemble proof of what will occur in the future, but are limited to the beliefs and expectations which are held towards what can occur.

Then the interview guideline was developed, see Appendix 8.2. The interviews were "open ended interviews where the same carefully constructed questions are posed to each participant" (Rutledge & Hogg, 2020, p.4). These questions are open-ended, to not subconsciously lead the answers. Closed questions were only used as follow-up questions to ensure a shared understanding of the answer given. According to DiCicco-Bloom & Crabtree (2006), deviations from the questions should be possible, since this "can be very productive as they follow the interviewee's interest and knowledge" (p.316), therefore semi-structured. Every interview was concluded with the question if there are any other topics that the interviewee would like to discuss.

Prior to the interviews, both routes were captured with an ActionCam, to simulate the short and longer route. The latter is partly mimicked since part of it will be in the new building. The distance of this part was using a map of the future plans, and this distance was walked in a different area that has a similar layout. The routes were recorded after consulting with the hospital's supervisors to ensure no privacy is violated. The ActionCam was strapped with vest and pointed to the ground to minimize the amount of people that could be recognized. Those people who were recorded and recognizable, were blurred. The videos were used in the interviews to question the interviewees' opinions on the difference between both routes and their potential influences.

The interview guideline and videos were shared with the interviewees a few days before the interview, allowing them to familiarize themselves with the questions. This generates more complete and representative answers, as confirmed by the interviewees. According to Haukås and Tishakov (2024), sharing interview questions prior to the interview can make the answers more programmed, but overall enhances the quality of the research. Furthermore, this would lead to less lengthy interviews, which is essential since delivering care is difficult to plan. The shorter the interviews, the smaller the chance of the interviews being a burden to the interviewees and their colleagues.

Then the data was collected. The interviews were voice-recorded, to ensure that all the answers are captured. These recordings were not shared with other persons. Access to the device is protected with a password, to which no one else has access. After the research, all the recordings were deleted. Furthermore, the names of the interviewees are not shared in this report, to ensure anonymity.

All of the above was shared and checked with the interviewees beforehand to receive their informed consent, see appendix 8.2. Additionally, the purpose of the research and the reason behind the sampling was explained, to make their contribution more transparent. It was also shared that participating will not affect their jobs as there is no personal gain.

This selection for this approach was motivated by four suggested key elements to help people make a new beginning (Cameron & Green, 2024). The purpose behind the change was sought, then a picture of the new look and feel of the new organization was mimicked with the map and videos. Lastly the interviews were aimed to involve the employees and give them a part to play in the plan to achieve an optimal outcome.

3.4 Data analysis

The interview analysis is an inductive thematic analysis, which "is a method for identifying, analyzing, and interpreting patterns of meaning ('themes') within qualitative data" Clarke and Braun (2017, p.297). This type of analysis identifies themes in the transcripts, that represent a patterned response in the data set (Braun & Clarke, 2006). It is suggested by Braun & Clarke (2006) to firstly read the data before analysing it, yet making notes for potential codes. One way of familiarizing is through transcribing the verbal data. The voice recordings were transcribed with Turboscribe.ai, which is compliant with Health Insurance Portability and Accountability Act (HIPAA) and SSL secured (Turboscribe.ai, 2023). This is less time consuming than transcribing them personally, which was crucial for this research. Silverman (2024, p.192) suggests to "always check the transcript against the recording", for accuracy (Braun & Clarke, 2006). The total data set existed of 367 pages of transcript.

When checking the transcripts for mistakes, the entire interviews were relistened. The transcripts were also checked for punctuation where needed, since Poland (2002, p.632) gives an example how punctuation can change the meaning of an answer: "I hate it, you know. I do" means something different than "I hate it. You know I do".

The analysis of the data set was done with ATLAS.ti, an online software application for qualitative data analyses (ATLAS.ti, 2025). Codes were generated for data which the researcher found interesting (Braun & Clarke, 2006), and have relation to the research question. A mix between inductive and deductive coding was used, i.e. a directed content analysis (Hsieh & Shannon, 2005). The interview questions were namely structured by the contents of the literature review. Therefore it already provided some possible codes. However, these codes were too general and failed to capture the essence of a response. Therefore, inductive coding was also applied, where a researcher generates codes through interpreting the dataset (Chandra & Shang, 2019). Afterwards, the codes were cleaned up, e.g. by combining "owning own ultrasound device" with "two ultrasound devices". Then the codes were sorted along potential overarching themes (Braun & Clarke, 2006) by going through all the interview transcripts and their coherent codes. This allowed to re-evaluate the assigned codes and gave context to the initial codes to ensure a better fitting overarching theme. This reduced the amount of codes with 30.64%.

The emerging themes were refined. Some were let go of, while others were combined. Firstly, the data extracts that are coded were analysed for a coherent pattern within a theme. Secondly, the themes themselves were checked for validity against the dataset (Braun & Clarke, 2006). Tables were made for the current situation at the hospital and future scenarios (explained in the first paragraph of chapter 4). In these tables, the themes were related to their overarching categories, to facilitate a structure for writing chapter 4 Results, thus encompassing the relevance of the themes to the broader story (Braun & Clarke, 2006). The final data structure that emerged from this is placed in table 1. This is also the structure of chapter 4 Results. In that chapter, these listed impacts are discussed along the different scenarios that come with this case. See the first paragraph of chapter 4 for an explanation of these scenarios.

Table 1 Final Data Structure

Operational Efficiency
1. Costs
2. Workload of employees
3. Waiting times for research
4. (Longer) transfer route of patients
Quality of Service
1. Definition
2. Quality of the ultrasound research
3. (Longer) transfer route of patients
Ideal Situation
Description of what the interviewees see as the ideal option.

3.5 Complementary Quantitative Data

3.5.1 Time measurements

Every day, starting from week 2, the duration of the longer route was walked and measured by the researcher four times a day, to make a prediction on how much extra time is spent on the longer route. Starting at the furthest patient room of the department 3North, all the way to where the new building will start. The aim was to measure the parts that differ between a longer and shorter route. Therefore the side tasks to the transfer were not measured, like the preparation of a patient in their room. The part on the third floor was measured to be able to calculate the average duration of the current route. With a stopwatch, the route was divided in four rounds. Round one starts at the last room and ends when pressing the elevator button. Round two starts when pressing the elevator button and ends when the doors of the elevator closed (with me inside). This starts round three, which ends when the elevator doors open on floor one. Round four ends when crossing the (approximate) line where the new building will start. The measurements were expanded with an estimation for the part of the route that will be in the new building. This namely cannot be measured as the new building does not exist yet. See appendix 8.3 for the calculations. The route outward of the patient rooms and the return route were both timed, but round one on the outward route equals round four on the return route. Therefore, the round numbers were changed to the location tags, see Appendix 8.4. The timings of the 3rd floor were used to make an estimate of how long a transfer to the ultrasound room (from 3North) takes on average at the moment.

The decision was made to do this every day at different times of day, in the first weeks of this research. There are namely many factors that can influence the waiting time for elevators. The individual measurements are therefore a snapshot of what could occur on the transfer route. By making 68 measurements, the representativeness of the sample is increased. Roughly halfway through the measurements, it was found that ultrasounds are made throughout the entire day, thus the times of measurement were adjusted so every interval of 30 minutes has at least one measurement. See appendix 8.6.

The measurements were done without wheelchairs, as it is not responsible to occupy wheelchairs 68 times while they are needed elsewhere. Therefore, several extra adjustments were made to make the routes more representative, like taking wide turns for the wider turn radius of wheelchairs. They also have inertia, i.e. it takes longer to get in motion from a stationary position (e.g. in the elevator), therefore walking out of the elevators started from all the way back in the elevator, to mimic this inertia. Sometimes, a few seconds were added to the measurement because a wheelchair would require people on hallways would make room, which was estimated to take up five seconds. The speed of walking with a wheelchair was tried to mimic by copying other transfers at the time of measurement.

3.5.2 Research data

These measurements were combined with data on how much this route is walked. These data were charted together with an operator, from the years 2020 to 2025 (year to date). Then the difference between the short and long route over the period of 2020 to 2024 (five years) was calculated in terms of total hours spend on transfers, total FTE's, and total costs of transfer.

Through this methodology, this research aims to fill the literature gap and give insight in machine sharing in service providing organizations, intra-organizational machine sharing in the healthcare sector, and machine sharing across departments. This methodology was anticipated to give insight into the different effects of machine sharing or separate usage, on organizational efficiency and quality of care delivered.

4. RESULTS

The aim of the interviews was to identify the effects of sharing and owning a medical device on a hospital's operational efficiency and quality of service delivered to patients. These effects are discussed by operational efficiency, followed by quality of service. Every subchapter begins with the results of the **Current Situation** to display how the current sharing principle has turned out in practice. Then the results on the two scenarios will be presented. In **Scenario 1**, the ultrasound device will be shared in remote proximity, either situated at the new building close to the CCU or at the current location. In **Scenario 2**, both departments have their own device. Thus close by for both the CCU and 3North. See appendix 8.1 for a map and further explanation of the exact locations. *Every argument in this chapter is derived directly from the interview analysis, and thus a view from the participants of this research.*

This chapter finishes with both the ideal situation that was depicted by the interviewees, and the quantitative analysis. The letters IP followed by a number (1 to 12), refer to a specific interviewee. The word "research" in this chapter refers to the patient research that is done with the ultrasound device. It does not refer to this report itself. The word "operators" refers to the lab technicians occupying the ultrasound device.

4.1 Operational efficiency

While reading this chapter, it is important that the right definition of operational efficiency in hospitals is kept in mind, as stated in chapter 2.1: "rapid access to care, minimum waiting time while at the same time delivering defect free quality care at the minimum cost" (Yaduvanshi and Sharma, 2017, p.3). From the interviews emerged that the following variables play an important role for operational efficiency: costs, the workload of employees, waiting times for research and the (longer) transfer route of patients. These are discussed below.

4.1.1 Costs

In **Scenario 1**, the majority of participants share that costs can be higher since more staff might be needed, and since the transfers take longer, they will be more expensive in terms of staff pay. Furthermore, **Scenario 2** two-device-scenario requires more operators, thus costs increase and this can lead to operator overstaffing, i.e. overcapacity, which is less efficient. "*That could be a disadvantage*"(IP7). Costs are also expected to increase through the purchase of the additional machine and maintenance. Though, the costs are not expected to outweigh the downsides of not owning a machine. Besides costs, some see no additional downsides. An alternative within this scenario would be that operators transfer between ultrasounds if no additional operators can be hired, but this is not preferred given their tight planning.

4.1.2 Workload of employees

To describe the role of the workload in this case, it was firstly important to ask interviewees about their current workload. A lot of interviewees showed that their current workload is manageable, while some experience a high workload. Their workload can, however, fluctuate unpredictably, for example because their workload depends on staff occupancy, the job title they exercise at a given day, or which day it is. Regardless, they share that some pressure is deemed to work stimulative.

According to some participants, the close proximity of the **Current Situation** firstly makes colleagues be close by, thus colleague support is nearby and quicker. Secondly, it is stated by participants that it prevents annoyances, is pleasant, and motivates job satisfaction. Thirdly, it ensures short lines of communication, "*And that is workload reducing*" (IP2). The current location also facilitates cardiologists to occasionally make ultrasounds, and operators to help with transfers. At the moment transfers are also done by other staff such as assistants, which is workload reducing for nurses. This is however dependent on the relative health of a patient, i.e. a more critical patient (code red) needs to be transferred by qualified nurses, a code green does not. Yet regardless of who transfers patients, there sometimes already is insufficient staff at departments.

On Mondays an ultrasound at another department is shared (outpatient clinic) to cope with the demand. This route is already a bit longer than the current one, but the route of **Scenario 1** is even longer. According to the majority of participants, it makes nurses spend more time away from their department and rely on their fellow nurses to jump in for them at the department while they are gone. In other words, this longer route shrinks the 'live' occupancy of the department. Whether colleagues can indeed give support, depends on colleague occupancy, since they also have their own tasks: "*The colleague must also have time for it*" (IP5). Thus the longer route puts a higher pressure on colleagues. This makes nurses eager to return to their department sooner, which reduces their ability to wait with a patient at the ultrasound until it is their turn, and can make a patient wait in the hallway more often. This is regarded as unpleasant. This all is considered to be less efficient and reducing their job satisfaction, which can lead to reputation damage and make the hospital less attractive for job-seeking nurses. Thus in scenario one the most worries regarded the pressure on nurses.

On the contrary, in **Scenario 2** this shifts to the operators, since the feasibility of this scenario is dependent on the amount of operators. It namely requires more operators, who should follow a (difficult) educational program of several years to specialize as an authorized operator. Regardless, participants consider this scenario more accessible and efficient. For example because employees will be less in a rush, which enhances interaction with patients and prevents that patients have to wait on the hallway. To realize this scenario, operators could build further on their flexibility by doing tasks for their other specialization(s) in the ultrasound room, since some of these are not location-bound. This would require clear communication and planning with the operators to prevent that they are frequently interrupted during these task, and thus get less work done.

4.1.3 Waiting times for research

Some interviewees do not see any downsides to the **Current Situation**. Those who do see downsides, see the waiting times as the most prominent one. The ultrasound room namely has tight capacity on certain days. Monday and Friday are busier, since no research is done in the weekends. A patient from either department could have priority, which makes patients from other departments wait longer for discharge. An ultrasound can namely be decisive in this: *"That patient could go home ... if the results were good"* (IP1). Yet, mainly because this is limited to two days, some believe that only one device is sufficient.

According to the interviewees, the degree of communication is a factor that can influence the waiting times for research as well. In the **Current Scenario** there are short lines of communication, which work quicker and is considered pleasant by the interviewees. Clear communication about the patient's vitality and who transfers the patient ensures timely colleague support and prevents that patients and operators have to wait on nursing staff to arrive. *"And then you've lost another 30 minutes ... which equals one patient less to research that day"* (IP9). The communication of the planning would preferably be communicated earlier so patients can be prepared (physically and mentally) earlier. The patients could even prepare themselves if the planning would be shared with them, which is currently not done.

In **Scenario 1**, some interviewees believe that the short lines of communication will be put to the test. A problem highlighted by lack of communication, is the already existing problem of support staff not being able to move patients out of wheelchairs. Nursing staff can. In case of miscommunication, the operator and patient have to wait for a nurse to arrive for support. However now the route is longer, thus they have to wait longer. This lowers the amount of patients that can be researched, i.e. a lower throughput rate. On the other hand, patients are unaware of the exact time their research is scheduled, thus a postponement prior to the transfer will likely go unnoticed.

Scenario 2 is expected to preserve the short lines of communication, and can lead to less waiting time, thus a higher efficiency.

4.1.4 (Longer) Transfer route of patients

The (longer) route of a patient transfer was such a prominent factor in the different scenarios, that it will be discussed as a separate influence on operational efficiency.

The participants share that **currently**, the ergonomics of transferring a patient are already suboptimal. A main factor in this is the wheelchair used for transfers. The supply of wheelchairs is already not sufficient and the quality of them is not up to par. This will have an effect on the physical health of the nurses and supporting staff. However, some nurses allegedly do not bother to change the height of the handlebars to improve ergonomics: *"Often people don't take the time to do that"* (IP6).

Transferring the patient to the ultrasound room is the starting point. But, if the vitality of a patient does not allow them to transfer to the ultrasound room, then the research is done at the patient's room. However, then the patient lies in their bed and the ultrasound device has to be moved through the hospital, which make these more difficult and more ergonomically challenging.

The advantages mentioned of this situation are that the route is short and accessible, which keeps personnel close to the department. The latter is advantageous because at this moment there is already pressure on employees, given that their job can be intense with few time available for the transfer. Due to the tight planning of 3North, there is almost no time for a longer transfer route. Therefore, this close proximity of the ultrasound is optimal, since it can lead to few time being lost due to transfers, thus care is delivered faster. An existing barrier on the current route however is the hallway. The hallways themselves are always clear for safety reasons. However, the rule of keeping the elevator square clear is not always adhered to. Which might make it clogged and hinder the transfer. Regardless, there is trust in colleagues that the hallways themselves are kept clear. *"Yes I am confident in that"* (IP3).

In **Scenario 1**, the route is considered to be longer, even *"too long"* (IP5). Argued from a nurses point of view, this scenario puts them in a dilemma: nurses are longer absent from their department, and may need to ask colleagues to step in and do the transfer for them. For example when they need to have an important discharge meeting with a patient. However, at the same time they are less inclined to ask colleagues for support as it is feels as imposing a burden on them. The interview results tend to explain why they feel this. Firstly, the route is longer, which can be intense for employees and puts more responsibility on the nurses and supporting staff. Secondly, they have to walk much more, and the currently used poor equipment makes the route intense for staff. The wheelchair quality generates doubt regarding the ergonomics of a longer route, and should be improved to make a longer route less physically challenging. Once the patient is delivered, the employee needs to walk back to their department, and then walk back towards the ultrasound room again after a few minutes. Since this will take much longer, they have much less time for small tasks, which will be postponed as a consequence. Thus, the duration of the ultrasound is ineffectively bridged, which makes that personnel is more in a rush and more prone to mistakes. On the other side, there is an inclination to do more ultrasounds at patient rooms. This increases pressure on operators. With these researches, it is namely not possible to save all the results in between the subsequent researches. Thus, the operators have to remember parts, making it more prone to mistakes.

The longer transfer route can lead to a lot more annoyances amongst staff. Different barriers on this route were identified during the interview. The main difference is considered to be the duration, length and unpredictable factors. The most prominent obstacle is the elevator, because of the movements and impracticalities that come with using elevators, for example having to leave and re-enter an elevator at other floors because other departments also use the elevators. However the chances of this happening are limited, since the patients being transferred (should) have the right of way. Elevators are also considered to have insufficient capacity. Other departments and visitors (accidentally) namely use the service elevators as well, though this is dependent on the time of day. The elevators can also have a defect, which happened during one of the measurements (outlier). The transfer is mainly bound to the service elevators because of their size. *"With a bed you are simply stuck to that particular elevator"* (IP11). A bed namely does not fit in the visitors' elevator. With a wheelchair however, these elevators are very occasionally used.

Additionally, the width of the hallway is deemed to influence the smoothness of the route. For example because a patient shuttle drives on the hallway of the first floor. If a patient is transferred in bed, and this shuttle needs to pass this hallway at the same time, then a bottleneck has emerged. Passing this shuttle with a bed is namely likely very tight, if not impossible at some points. Especially on busy days this route can lead to logistical bottlenecks.

The longer route has several effects on job satisfaction of nurses. More time spent away from the department can lead to more dissatisfaction, as do more walking and getting less tasks done (for both operators and nurses). But this also affects the job satisfaction of support staff, since more transfer will be done by qualified nurses and less by supporting staff, given the higher risk for the patient. This diminishes the job satisfaction of the latter group, since these transfers likely contributed to their job satisfaction. All these downsides contribute to more complaining to colleagues.

This route also is considered to have an influence on patient well-being. As mentioned, in the current situation, it is possible for patients to walk to the ultrasound room themselves. However, less patients will be able to walk the longer route, which leads to more dissatisfaction amongst patients. It would at least require route guidance, to simplify the route. Furthermore, if anything were to happen during the transfer, then the colleague support takes longer. Thus the longer route can lead to a slower response, but also to longer waiting times. It demands a lot more patience from the patients. For example because some nurses will prioritize the ultrasound over other care, since else the operator is delayed. Thus it has an effect on other patients by being less efficient, and can lead to a higher throughput time.

With regards to the route, the **Scenario 2** is considered to mainly have positive effects. Firstly, not having to move the ultrasound device is an advantage, *"because the device is quite heavy and not very easy to handle"* (IP9). Secondly, faster care is delivered given the short route and more capacity per department. Thirdly, care is in close proximity, i.e. care is kept close to the patient. Fourth, there is less pressure on employees. They are less in a rush, have to walk less and have less annoyances. The latter has a positive effect on their job satisfaction. Fifth, there are less barriers on the route. Therefore it is safer, more efficient and less lengthy. Lastly, the patient can be given more autonomy by allowing them to walk themselves.

4.2 Quality of service

4.2.1 Definition

While reading this chapter, it is important that the right definition of quality of service is kept in mind: It can be technical, i.e. the ways inputs are transformed into health outcomes; and functional, i.e. characteristics that influence an experience beyond technical competences (Kenagy et al., 1999). It firstly is relevant to discuss how the interviewees define quality of service. The majority of the interviewees focused on putting the patient at the center. Even though there can be a difference in perceived quality of care between nurses and patients, quality of care involves that the patients are the focus, and tailored and complete care is delivered close to the patient, by having time for the patient, communicating with the patient, i.e. informing the patients and involving them in decision-making, to ultimately even give them a certain degree of autonomy. The goal should be to earn the trust of the patient and ensure patient satisfaction. It is deemed as important to be friendly, have respect for the patient and be respectful towards the patients' family. Thus showing a professional attitude, which is sometimes lacking, according to IP6: *"Because I also know that sometimes entire conversations go back and forth [between employees], while the patient is still lying there in bed … I don't think that's nice"*. Lastly some interviewees mentioned that the quality of the research itself is important, and that it should be provided equally.

Important to note is that the care should not be endless, instead it should be appropriate, i.e. knowing when extra care does not add any more value, which is patient dependent. Regardless of the extent of care, it should be sustainable and according the guidelines.

4.2.2 Quality of the ultrasound research

The quality of service can be affected by equipment. The equipment in the ultrasound room in the **Current Situation** is considered to be ergonomic, which ensures better quality of research. However, sometimes the ultrasound is done at the patient's room, if the patient's condition does not allow them to go to the ultrasound room. Apparently it is standard practice and according to guidelines to have some kind of ultrasound close to the CCU. Whether a handheld ultrasound meets these guidelines was not clear, *"but you can't really do research of high quality with that"* (IP8).

4.2.3 (Longer) Transfer route of patients

It is relevant to identify what the interviewees see as a successful transfer. First, the route should be safe. Second, a patient should stay healthy throughout the transfer. The patient evaluation prior to a transfer is an attempt to maximize these chances. There have namely already been some calamities during transfers. The evaluation and the preference of having enough time to do the full transfer, i.e. not leaving the patient to wait by themselves in front of the ultrasound room, shows that the patient is the main focus. Third, the route should be logically organized and cost the employees little effort. Lastly, the transfer is successful when it is on time, i.e. with no waiting time. The transfer route should not be the reason for delay in ultrasound research.

In the **Current Situation**, the patient evaluation puts pressure on employees, since they carry and feel responsible for what happens to their patients. This is partly due to the fact they are the ones who determine whether a patient is vital enough to be transferred. For example, when a high risk patient is lying in isolation, then this patient is treated with more precaution. Either the ultrasound research is done at the patient's room or at the ultrasound room. In case of the latter, it will be thoroughly cleaned afterwards. For the average other patient, a wheelchair is standard. Some believe that a wheelchair is used too easily and thus reducing patient autonomy. Some patients can namely walk to the research themselves, given the close proximity.

There are some other downsides mentioned of the current route. Namely that the equipment prohibits a live connection of the patient's vitals during the transfer. Besides this being a risk for the patient's health, it can also be considered an annoyance of the staff. The patients tend to notice these and other kinds of annoyances already, and expectedly will notice annoyances of a longer route, regardless of the professional attitude from staff used to hide annoyances towards patients. *"It will shine through subconsciously"* (IP4). Apart from that, the current situation leads to an overall pleasant interaction. At the moment, work is already done to make more time for interaction with patients, which enhances job satisfaction, and perhaps also satisfaction for patients. Yet regardless of the scenario, patients are already hard on themselves and often overwhelmed by everything that has happened to them when they end up in the hospital.

The opinions on the effects of the longer route in **Scenario 1** are more divided. Some namely believe that there will be more interaction and enhance job satisfaction, yet make no difference for patients. Others believe that there will be less interaction. Notably, IP6 mentions both ends. They namely think that there is more time for interaction, yet the interaction will be more abrupt given the rush an employee likely will be in. The detailed difference in more or less interaction can also be explained by IP9. They namely mention that it is dependent on who's point of view is argued from. Employees who do transfers will have more interaction with those patients, but less interaction with other patients and less time for a patient's family. On the other hand, operators will have less interaction with patients since they will treat less patients.

The same goes for the quality of interaction. Some state that a longer route has no effect on the interaction with the patient. Others state that it can be influenced by the mode of transfer. This is firstly given that a longer route will lead to more reconsiderations of the proper mode of transport. There will be more transfers with a bed to ensure safety, since it takes longer for good and supportive equipment to arrive if anything were to happen during the transfer. Therefore good and supportive equipment should be within reach, like a DECT phone, AED's or crash carts for resuscitation. Secondly, more transfers in bed will influence the interaction, since a bed namely requires two staff members. They will also talk with each other, and less with the patient. This mode of transfer also influences the quality of the research itself, as an ultrasound research is more difficult when a patient lies in a bed.

Furthermore the longer route has poor (if not worse) signal (i.e. poor reception/connectivity). Whether a patient can walk themselves is dependent on their cognitive abilities. According to IP7, less patients will walk back, thus reducing the patient's autonomy. The longer route also can lead to a slower response time from colleagues when a calamity occurs, thus there is more risk for the patient's health. Moreover, often an ultrasound research is needed to diagnose a patient, i.e. chart their health status. This means that the vitality and health status of the patient are not always known prior to the transfer. Therefore the chances of a calamity are unknown.

The longer route is expected to have a negative effect on patient wellbeing. It can lead to less tailored care and may make patients feel like being treated as a number. Employees being more in a rush and the route being makes that less complete care can be delivered, since waiting with the patient until it is their turn is considered to be part of complete care. It will make the stay in the hospital more intense for patients. The route goes through areas that are considered to be too crowded, the elevators have a risk for patient's health and feel unsafe, and the privacy of the patient is at higher stake with the longer route. The latter regards the clothing of the patient while being transferred through a busy part of the hospital. *"Not that they are transferred in merely diapers"* (IP9). Yet, a patients perception of the route is likely dependent on their vitality. Stable patients might like the transfer and see it as a fun trip through the hospital, while it is likely uncomfortable and too long for critical patients. Additionally, older patients tend to already feel cold during the transfer, but expectedly even more so during the longer transfer.

Scenario 2 is expected to give more control over the process, and higher quality of research since an ultrasound is always nearby.

4.3 Ideal Situation

The interviewees were also asked for their ideal route and solution. For the latter, the responses can be categorized over two categories: sharing in remote proximity, i.e. different floors and a longer transfer route, and owning an own device, i.e. same floor and nearby.

The ideal route would be short and smooth. That would include a route with wide enough hallways; no waiting time; no elevators, i.e. *"ideally of course staying on the same floor"* (IP5); avoiding other obstacles (e.g. narrow hallways, difficult turns) and crowded areas; and having a supportive infrastructure, which route guidance could be an element of. All in all, ideally the patient should be able to comfortably find the ultrasound room, if they can walk themselves. Notably, these elements explain why many see no downsides to the current route, they share many similarities.

The majority of the interviewees would prefer two ultrasound devices. Thus one at the new building close to CCU and one at the current location, near 3North on the third floor. This would make ultrasounds at the ultrasound room more accessible, which is preferred. Notably, one interviewee argued that it could be a reasonable option to only buy an additional ultrasound, not also a hometrainer. Both are shared, but the latter is used much less, and mostly relevant for the CCU. Another interviewee stated that 3North would be able to bridge the renovation. Someone else suggested to share an ultrasound with the outpatient clinic if possible, situated on the first floor.

4.4 Quantitative Results

The old route was calculated to take an average of 49.13 seconds (walking it once), measured from the last room of 3North to the ultrasound room. The new route, including the new building, is calculated to take an average of 4 minutes and 21.76 seconds (walking it once). One measurement stood out, as it totaled 13 minutes and 44.62 seconds, which is caused by a defect of one of the four service elevators. See Appendix 8.7 for a boxplot of the timings of the longer route. Of this time, an average of 1 minute and 47.94 seconds is spent waiting on elevators. See Appendix 8.8 for a boxplot on waiting times for elevators.

In consultation with an operator, research data was identified. These numbers include three types of research for which the route is taken. See appendices 8.9 to 8.12 for the calculations. These led to the following results. Over five years (2020-2024) an average of 417.11 hours is spent on transferring the patients. This would be 2,222.34 hours with the longer route, which is 1805.23 hours more. Of these 2,222.34 hours, 41% is spent waiting on elevators, 49% is spent walking, and 10% spent in elevators. The short route (**Scenario 2**) costs €17,200.22 in terms of staff pay, whereas the longer route (**Scenario 1**) costs €91,641.14, leading to a difference of **€74,440.92**. These wages are retrieved from Nederlandse Vereniging van Ziekenhuizen (2025), and refer to the agreed wages for the 1st of August 2026. Since the renovation is happening over a few years, this is the closest data available.

The former calculation assumes that every transfer is done by a nurse with a wheelchair. These calculations should therefore be seen as a minimum. However, this is not realistic. Transfers with a bed namely take longer. Furthermore, this mode of transfer requires two staff members. Yet transfers for code green patients are currently also done by volunteers and some patients walk themselves, thus these transfer do not have direct staff costs. Therefore both the current and projected costs might be inflated. Accounting for these aspects with an educated guess of their proportions, leads to the following results: costs of the short route (**Scenario 1**) is €16,012.67; the long route (**Scenario** 2) costs €110,057.11, leading to a difference of **€94,044.44**.

5. DISCUSSION

5.1 Theoretical implications

The results offer insights in how the potential impacts interrelate with operational efficiency, quality of service, and each other. The results of this research cannot be verified with previous research of machine sharing in hospitals, since there is none. However, the results can be linked to how operational efficiency and quality of service are defined, and to the findings of machine sharing in the agricultural sector. Therefore the results will be interpreted and linked to the literature were possible, and can act as a nuance on the machine sharing principle in other sectors. The results are charted in both a simplified framework and a detailed framework. The simplified framework was based on the core points of the detailed framework. See figure 1 and Appendix 8.13 for the former or Appendix 8.14 for the latter.

Figure 1 shows the relationships between the core factors. This means the following. Start at "route length": the longer the route, the higher the workload, hence the + next to the quadrant of workload; and the higher the workload, the lower the operational efficiency, hence the – below the arrow to operational efficiency.

5.1.1 Operational efficiency

The interviewees answered that the transfer route would ideally not require using elevators. Using stairs is not relevant since these cannot be used with a wheelchair or a bed. Therefore a route is considered a *long* route if the transfer requires switching floors with an elevator, and a *short* route if this is not the case. Sharing a device either occurs with a short route (current situation) or with a long route (scenario 1), whereas owning a device only occurs with a short route (scenario 2).

Sharing a device has a positive relationship on the operational efficiency through waiting times for research. The capacity of that machine namely has to be shared. The more machinery is shared, the more waiting time for research. The suggestion was made to share the time of research with patients

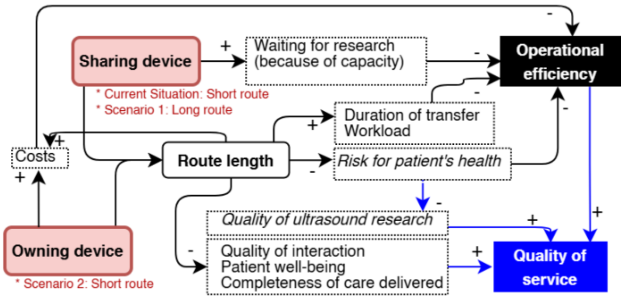


Figure 1 Impacts of sharing vs owning a device on operational efficiency and quality of service

so they can prepare themselves if possible, but it should be kept in mind that this means that the patient will also be aware of postponements of the research, which can influence the perceived inefficiency.

Figure 1 represents the direct results of the interviews. However, since sharing or owning are opposites, it may be that an advantage of sharing a device is considered a disadvantage of owning a device and vice versa. Therefore (although not directly mentioned in the interviews) owning a device can lead to less "waiting for research" given that the capacity of the device is not shared. The other effects are influenced by the length of a route. Overall a shorter route is beneficial, regardless of sharing or owning a device. However, in this scenario, sharing with a short route will not be possible in the near future. Hence, owning a device is the only scenario benefitting from the advantages of a short route.

The results contradict the literature study on the current workload of employees. As mentioned, Centraal Bureau voor de Statistiek (2022) states that the majority of employees experience a high workload. The results however show that the workload was manageable for many at the moment, which shows that the statistics of CBS are an aggregate and not by definition generalizable over full departments in a hospital.

According to Bogyo (2024), a higher workload leads to employees having less time and attention for patients, which can increase the dissatisfaction of employees, as stated by Verest et al. (2019). The results bring further nuance to this. In this situation it is namely not the workload that influences the time spent on patients, but the length of the transfer route. It also increases the risk for a patient's health, due to a lack of live signal to monitor the patient, a slower response to calamities during the transfer, and lastly because the health risk of the patient is not always known prior to the transfer. This is in accordance with Shirley and Bion (2004), suggesting to ask the question "Is this transfer really safe?" (p.1508), since "there are many potential risks associated with transporting the critically ill patient" (p.1508). This affects the *defect free* and *rapid access to care* elements of operational efficiency as identified in the literature. Moreover, the results show that the length of the route might lead to undercapacity at the department, which is related to more mistakes being made. This is in accordance with the findings of Bogyo (2024). Bogyo (2024) also states that a higher workload leads to reputation damage, which is confirmed by the results, as IP4 states: *"They [nurses] would want to work in a hospital where the things are efficiently organized, and where they can work pleasantly…"*. This, together with the insufficient growth of healthcare staff (Dantuma, 2024), puts more stress on the hospital as a whole.

The literature study shows that sharing machinery is done in the agricultural sector to drive costs down (Puschmann & Alt, 2016). The quantitative analysis supports this. The purchasing costs and costs of an extra operator total at €296,777.81 (**Scenario 2**), see appendix 8.12. The machine is depreciated over 7 years, so when taking the costs of the transfer route for **Scenario 1**, this is **€134,792.94** more than **Scenario 1** (calculation with assumptions), which equals **€26,958.59** a year. A total of 1805.23 hours are spent on transfers more during these five years. This equals about 0.246 FTE per year, over both departments. See appendix 8.12 for the exact calculation. Thus, the quantitative analysis supports the findings in the agricultural sector: sharing machinery drives costs per organization (in this case the department) down. Minimizing the distance that is walked therefore can take away costs, but it does not necessarily lead to less financial costs overall, unlike the hospital in Virginia mentioned in chapter 2.2.3.

5.1.2 Quality of service

Since there is lack of literature on the effects of machine sharing in the service industry, no literature was found to compare the results on the quality of service. Which is why the results on quality of service are novelties. This subchapter discusses the relationships with quality of service as depicted in figure 1.

A definition of quality by employees was not found in the literature study, which is why they were asked to share their perception in the interviews. These overlap most with the *service* element of quality. Namely that the patient should be the main focus while providing complete care with a professional attitude.

The literature study did show that a patient's perception of quality is defined through the interaction with employees (Amin & Zahora Nasharuddin, 2013). The amount of interactions between staff and patients can affect the job satisfaction of employees. A longer route expectedly leads to less interaction between operators and patients, and more interaction between nurses and patients. More interactions can lead to higher job satisfaction, which can lead to a higher quality of interaction, thus a higher (functional) quality of service (and vice versa). However, this positive effect on job satisfaction likely does not outweigh the negative effect of the workload on job satisfaction.

Furthermore, the length of the route influences the quality of an interaction, regardless of a professional attitude. Additionally, the risk for a patient's health influences the quality of the research. The higher the risk for the patient's health in a transfer, the more often a bed for transfer. This can worsen the quality of interaction, since the two staff members will also talk with each other, which a patient can find unpleasant. Thus worse quality of interaction and worse quality of service. These transfers in bed also negatively affect the quality of the ultrasound research, as do researches at patients rooms. The latter are done more often if the risk for a patient's health increases because of a transfer. This location diminishes the quality of the research itself, given the available equipment at these rooms, and negatively affects the technical quality of service delivered.

Two last core factors that can influence quality of service are patient well-being and completeness of care delivered. The former is affected by three main factors. Firstly the length of the route, since less patients will be able to walk to the research themselves with a longer route, which is expected to lower their well-being. Secondly, a longer route can lead to more unrest for the patient due to crowded areas and elevators. Thirdly, the patient's privacy is at higher stake. Their clothing should be appropriate to preserve this privacy while going through the hospital. The completeness of care that is delivered is also dependent on the length of the route. It is namely positively related to the amount of times patients will have to wait in the hallway alone, negatively related to the amount of control employees have over the process itself, and negatively related to the time that can be spent with a patient's family. These elements can make care complete. The latter two are positively related to the completeness of care delivered, while patients waiting in the hallways alone is negatively related to completeness of care.

5.2 Practical implications

This research can support hospitals in the decision-making process of buying or sharing machinery between departments. The chosen methodology of in-depth interviews and a quantitative analysis can be seen as an example of how the preservation of service quality can still be one of the top priorities in a decision-making process, while involving employees to make them part of the change process and make it make sense, yet at the same time including financial data. The emerging overviews can be used in this decision-making process to better understand the relationships between factors inside a hospital, and identify underlying factors that can be changed to improve the operational efficiency and quality of service. This research also highlights the important role that intangible factors like job satisfaction and patient well-being play in an organizational change process. Thus the role that humans in an organization play on the efficiency and quality of care delivered.

What stood out is that scenario 2 can be optimized further by operators doing their tasks of their other specializations in the ultrasound room(s). But, this needs to be clearly planned with them to prevent excessive disturbance and loss of productivity. This scenario would require increased focus on acquiring more operators to occupy these devices. An alternative solution would be placing the ultrasound somewhere halfway the longer transfer route, which might drive costs of transfer down to a certain extent. But this would still not take away most of the disadvantages with a longer route. In fact, then both departments have a longer transfer route.

Several counter measurements emerged from the interviews that can be implemented if the decision were to made to share one machine. It would require stricter planning of researches to prevent overburdening them with transferring the ultrasound device. Furthermore, to unburden nurses to some extent, electrical wheelchairs, i.e. push support could be bought.

To bring further nuance to the financial analysis, it would be recommended to record the type of staff member, and from which department patients are transferred would make it possible to chart the costs of the transfers more precisely, e.g. extra FTE's spent *per department*.

5.3 Limitations & Future Research

This research is characterized by some limitations that might influence its results. The case study existed of one organization and specific departments, and might therefore not be representative for the full healthcare sector. The chosen case is also one specific aspect of the service-providing industry. Further research could focus on a case study of multiple hospitals, other departments, other types of service-providing organizations, even other countries, to better understand machine sharing in the healthcare and broader service providing sectors. Besides, this hospital has not tested the impacts of sharing versus owning a medical device on operational efficiency and quality of service. Therefore the results are based on experiences and expectations on how certain changes might affect the operational efficiency and quality of service. Research could be extended to hospitals where such a decision-making process has occurred, to research the actual effects of sharing versus owning a machine. This could be extended by focusing on the perception of the patients themselves, after experiencing such a longer transfer route.

The videos used in the interviews were a snapshot of what could happen on a transfer, thus not fully representative for the transfer routes. The interview coding was done by one researcher and not peer reviewed, therefore there is no proven intercoder reliability, limiting the analysis to the interpretation of the researcher, which makes it more prone to researcher bias.

The time measurements should be seen as a minimum, since they were done without a wheelchair or a bed, regardless of the attempts that have been made to increase the representativeness of the measurements, The financial analysis was limited to the costs of transfer and costs of purchasing an additional machine, as these costs are the direct opposites of each other. However, there are more factors that can influence the costs of either alternative, maintenance, electricity, and costs of complementary equipment. These could be included if a more detailed financial analysis would be done at the hospital.

5.4 Conclusion

This research aimed at answering the following central research question: *What are potential impacts on operational efficiency and patient care quality by sharing in contrast to owning medical devices within a hospital?*

On the one hand, the results have shown that sharing a machine in itself has a negative relationship with operational efficiency because of the capacity that is shared, since this makes patients wait longer for research, and the costs of a longer route. A short route leads to a positive relationship. Owning a device solves this. However it is also negatively related to operational efficiency through higher costs. On the other hand, the transfer route of patient plays a very important role. It affects the operational efficiency negatively, since it takes longer to deliver care, increases the chances of mistakes being made, puts higher risk on the health of a patient and increases cost of transfer. It influences the quality of care through the effect on patients, i.e. the interactions with patients and their well-being. Furthermore, the longer the route, the less complete care and the lower the quality of the research itself, which both lead to less quality of care, and vice versa. Lastly, the higher the operational efficiency, the higher the quality of care and the better the reputation of a department.

So even though the financial analysis concludes that scenario 2 is more expensive than scenario 1, it fails to capture the intangible elements like workload, job satisfaction, patient well-being and patient safety. Therefore, if the department is will to invest **€26,958.59** a year to avoid all the negative potential effects on operational efficiency and quality of care, then the advice would be to purchase the second device.

6. ACKNOWLEDGEMENTS

I would like to genuinely thank my supervisors from both the UT and the hospital. I would like to thank dr. Barbara Kump for her constructive feedback during this whole bachelor thesis. But more importantly, for her open and understanding approach to give this feedback. I would like to also thank Erwin, Ramon, Dominique, Tanja, and Anne for helping me with any question I had, to help me get started in this (at that point) unfamiliar setting, but most importantly to support me on a personal level whenever needed. I would also like to thank Simone for initiating this assignment, without her attentiveness I would not have had this bachelor assignment. Then I would also like to thank the interview participants, Nienke, Rob, Marijn, and every other person that has contributed to this research. I could simply not have made this bachelor thesis without their input and support. And a warm thank you to all my other colleagues who have made these few weeks a pleasant experience. Finally I want to thank my close family and friends for supporting me behind the scenes.
During the preparation of this work, the author used Turboscribe.ai in order to transcribe interview recordings, and ChatGPT in order to brainstorm on calculations in Excel. After using this tool/service, the author reviewed and edited the content as needed and takes full responsibility for the content of the work.

7. REFERENCES

Amin, M., & Zahora Nasharuddin, S. (2013). Hospital service quality and its effects on patient satisfaction and behavioural intention. *Clinical Governance: An International Journal*, *18*(3), 238–254. https://doi.org/10.1108/cgij-05-2012-0016

ATLAS.ti. (2025, February 11). *ATLAS.ti | The #1 Software for Qualitative Data Analysis*. ATLAS.ti. https://atlasti.com/

Benjaafar, S. (1995). Machine sharing and performance of cellular manufacturing systems. *Journal of Materials Processing Technology*, *52*(1), 91–101. https://doi.org/10.1016/0924-0136(94)01574-k

Benjaafar, S. (1996). Modeling and analysis of machine sharing in manufacturing systems. *European Journal of Operational Research*, *91*(1), 56–73. https://doi.org/10.1016/0377-2217(94)00278-9

Bertnum, A. B., Berg, R. K., Bergstøl, S., Strandhagen, J. O., & Semini, M. (2023). Effect of Machine Sharing in Medical Laboratories. *IFIP Advances in Information and Communication Technology*, 515–530. https://doi.org/10.1007/978-3-031-43666-6_35

Blaettchen, P., Taneri, N., & Hasija, S. (2020). Sharing of Heavy Equipment. *INSEAD Working Paper Series*, *43*.

Bogyo, I. (2024, October 22). *Werkdruk in de zorg*. Effectory.com; Effectory. https://www.effectory.com/nl/kennis/werkdruk-in-de-zorg/#wat-voor-impact-heeft-werkdruk-in-de-zorg

Boyce, C., & Neale, P. (2006). *Conducting in-depth interviews: A guide for designing and conducting in-depth interviews for evaluation input* (Vol. 2). Pathfinder international.

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, *3*(2), 77–101. https://doi.org/10.1191/1478088706qp063oa

Brown, J. (2016, November 21). *MIT's Approach to Design Thinking*. Medium; UX Qatar. https://medium.com/ux-qatar/mits-approach-to-design-thinking-e301fcf2a82a

Browne, K., White, N., Tehan, P., Russo, P. L., Amin, M., Stewardson, A. J., Cheng, A. C., Graham, K., O'Kane, G., King, J., Kiernan, M., Brain, D., & Mitchell, B. G. (2023). A randomised controlled trial investigating the effect of improving the cleaning and disinfection of shared medical equipment on healthcare-associated infections: the CLEaning and Enhanced disiNfection (CLEEN) study. *Trials*, *24*(1). https://doi.org/10.1186/s13063-023-07144-z

Cameron, E., & Green, M. (2024). *Making Sense of Change Management.* (6th ed.). Kogan Page Publishers.

Centraal Bureau voor de Statistiek. (2022, November 16). *Helft zorgwerknemers vindt werkdruk te hoog*. Cbs.nl. https://www.cbs.nl/nl-nl/nieuws/2022/46/helft-zorgwerknemers-vindt-werkdruk-te-hoog

Chandra, Y., & Shang, L. (2019). Inductive Coding. *Qualitative Research Using R: A Systematic Approach*, *20*(1), 91–106. https://doi.org/10.1007/978-981-13-3170-1_8

Clarke, V., & Braun, V. (2017). Thematic Analysis. *The Journal of Positive Psychology*, *12*(3), 297–298. https://doi.org/10.1080/17439760.2016.1262613

Dantuma, E. (2024, March 4). *Dutch healthcare continues to see substantial growth despite capacity limitations*. ING Think; ING. https://think.ing.com/articles/dutch-healthcare-keeps-on-growing-substantially-despite-persistent-capacity-constraints/#a8

DiCicco-Bloom, B., & Crabtree, B. F. (2006). The qualitative research interview. *Medical Education*, *40*(4), 314–321. https://doi.org/10.1111/j.1365-2929.2006.02418.x

Etikan, I., Musa, S. A., & Alkassim, R. S. (2016). Comparison of convenience sampling and purposive sampling. *American Journal of Theoretical and Applied Statistics*, *5*(1), 1–4. https://doi.org/10.3898/175864316818855248

European Commission. (2021). *State of Health in the EU The Netherlands Country Health Profile 2021 The Country Health Profile series*. https://health.ec.europa.eu/system/files/2021-12/2021_chp_nl_english.pdf

FlaQuM. (2021, May 22). *Visiemodel*. Flaqum.org. https://flaqum.org/visiemodel/

Hanefeld, J., Powell-Jackson, T., & Balabanova, D. (2017). Understanding and measuring quality of care: dealing with complexity. *Bulletin of the World Health Organization*, *95*(5), 368–374. https://doi.org/10.2471/blt.16.179309

Harris, A., & Fulton, M. (2000). *Farm Machinery Co-operatives An Idea Worth Sharing*.

Haukås, Å., & Tishakov, T. (2024). Sharing interview questions in advance: Methodological considerations in applied linguistics research. *European Journal of Applied Linguistics*, *0*(0). https://doi.org/10.1515/eujal-2023-0045

Hod, R., Malmon, O., & Zimlichman, E. (2016). The Relationships between Hospital Service Quality and Operational Efficiency: an Alternative Model. *Health Economics & Outcome Research: Open Access*, *2*(3). https://doi.org/10.4172/2471-268X/1000119

Hsieh, H. F., & Shannon, S. E. (2005). Three Approaches to Qualitative Content Analysis. *Qualitative Health Research*, *15*(9), 1277–1288. https://doi.org/10.1177/1049732305276687

Irani, S. A., Cavalier, T. M., & Cohen, P. H. (1993). Virtual manufacturing cells: exploiting layout design and intercell flows for the machine sharing problem. *International Journal of Production Research*, *31*(4), 791–810. https://doi.org/10.1080/00207549308956757

Kenagy, J. W., Berwick, D. M., & Shore, M. F. (1999). Service Quality in Health Care. *JAMA: The Journal of the American Medical Association*, *281*(7), 661–665. https://doi.org/10.1001/jama.281.7.661

Larsén, K. (2010). Effects of machinery-sharing arrangements on farm efficiency: evidence from Sweden. *Agricultural Economics*, *41*(5), 497–506. https://doi.org/10.1111/j.1574-0862.2010.00461.x

Ministerie van Volksgezondheid, Welzijn en Sport. (2025). *Stories Dashboard - Zorg en welzijn (breed) - Nederland*. Prognosemodelzw.nl. https://prognosemodelzw.nl/dashboard/stories-dashboard/zorg-en-welzijn--breed-

Nederlandse Vereniging van Ziekenhuizen. (2023, July 21). *NVZ: Financiële druk op ziekenhuizen loopt op | NVZ*. Nvz-Ziekenhuizen.nl. https://nvz-ziekenhuizen.nl/actualiteit-en-opinie/nvz-financiele-druk-op-ziekenhuizen-loopt-op

Nederlandse Vereniging van Ziekenhuizen. (2025). *Salarisschalen, premies & vergoedingen | NVZ Cao Ziekenhuizen*. Cao-Ziekenhuizen.nl. https://cao-ziekenhuizen.nl/salarisschalen-premies-vergoedingen

Niasse, N. (2023). Limiting Misleading ideas about the History of Grounded Theory Methodology. *International Journal of Qualitative Methods*, *22*, 160940692211494. https://doi.org/10.1177/16094069221149486

Poland, B. D. (2002). Transcription quality. In *Handbook of interview research: context and method* (pp. 629–649). Sage.

Puschmann, T., & Alt, R. (2016). Sharing Economy. *Business & Information Systems Engineering*, *58*(1), 93–99. https://doi.org/10.1007/s12599-015-0420-2

RIVM. (2020). *Zorguitgaven blijven tot 2060 stijgen, gemiddeld met 2,8 procent per jaar | RIVM*. Rivm.nl. https://www.rivm.nl/nieuws/zorguitgaven-blijven-tot-2060-stijgen-gemiddeld-met-28-procent-per-jaar

RIVM. (2024). *Ziekenhuiszorg | Gebruik | Volksgezondheid en Zorg*. Vzinfo.nl. https://www.vzinfo.nl/ziekenhuiszorg/gebruik#:~:text=Aantal%20ziekenhuisopnamen%20gedaald,als%20het%20aantal%20klinische%20opnamen

Rutledge, P. B., & Hogg, J. L. C. (2020). In-Depth Interviews. *The International Encyclopedia of Media Psychology*, 1–7. Researchgate. https://doi.org/10.1002/9781119011071.iemp0019

Schoch, K. (2020). Case Study Research. In *Research Design and Methods: An Applied Guide for the Scholar-Practitioner* (pp. 245–258). SAGE Publications, Inc.

Sheikhzadeh, M., Benjaafar, S., & Gupta, D. (1998). Machine Sharing in Manufacturing Systems: Total Flexibility versus Chaining. *The International Journal of Flexible Manufacturing Systems*, *10*, 351–378. https://doi.org/10.1023/A:1008057504351

Shirley, PeterJ., & Bion, JulianF. (2004). Intra-hospital transport of critically ill patients: minimising risk. *Intensive Care Medicine*, *30*(8). https://doi.org/10.1007/s00134-004-2293-6

Silverman, D. (2024). *Interpreting Qualitative Data* (7th ed.). Sage Pub.

Slack, N., Brandon-Jones, A., & Burgess, N. (2022). *Operations Management* (10th ed.). Pearson Education Limited.

Turboscribe.ai. (2023). *TurboScribe*. Turboscribe.ai. https://turboscribe.ai/l/medical-transcription-for-healthcare-professionals

Verest, W., de Veer, A., de Groot, K., & Francke, A. (2019). *Kwaliteit en veiligheid van zorg aan cliënten - Verpleegkundigen, verzorgenden, begeleiders en praktijkondersteuners over wat ze nodig hebben voor goede zorg* (1st ed.). NIVEL .

Xue, H., & Zhang, R. (2023). Quantitative Research on the Satisfaction of Shared Medical Equipment Under Sharing Economy. *Advances in Economics and Management Research*, *3*(1), 126. https://doi.org/10.56028/aemr.3.1.126

Yaduvanshi, D., & Sharma, A. (2017). Lean Six Sigma in Health Operations. *Journal of Health Management*, *19*(2), 203–213. https://doi.org/10.1177/0972063417699665

8. APPENDIX

8.1 Map of hospital

Figure 2 shows the 3rd floor. The red line represents the current route, which ends in the center of the map. This is where the ultrasound device is located in the current situation, and will be located in scenario two. In scenario one, there are two alternatives. It can either be located on the third floor, but also in the new building, see figure 4. It is located "behind" the classified box. The blue route represent the route that will be walked to reach this location, starting on the third floor, down to the first floor, then down to the ground floor. This was the route that was measured.

Figure 2 Map of 3rd floor

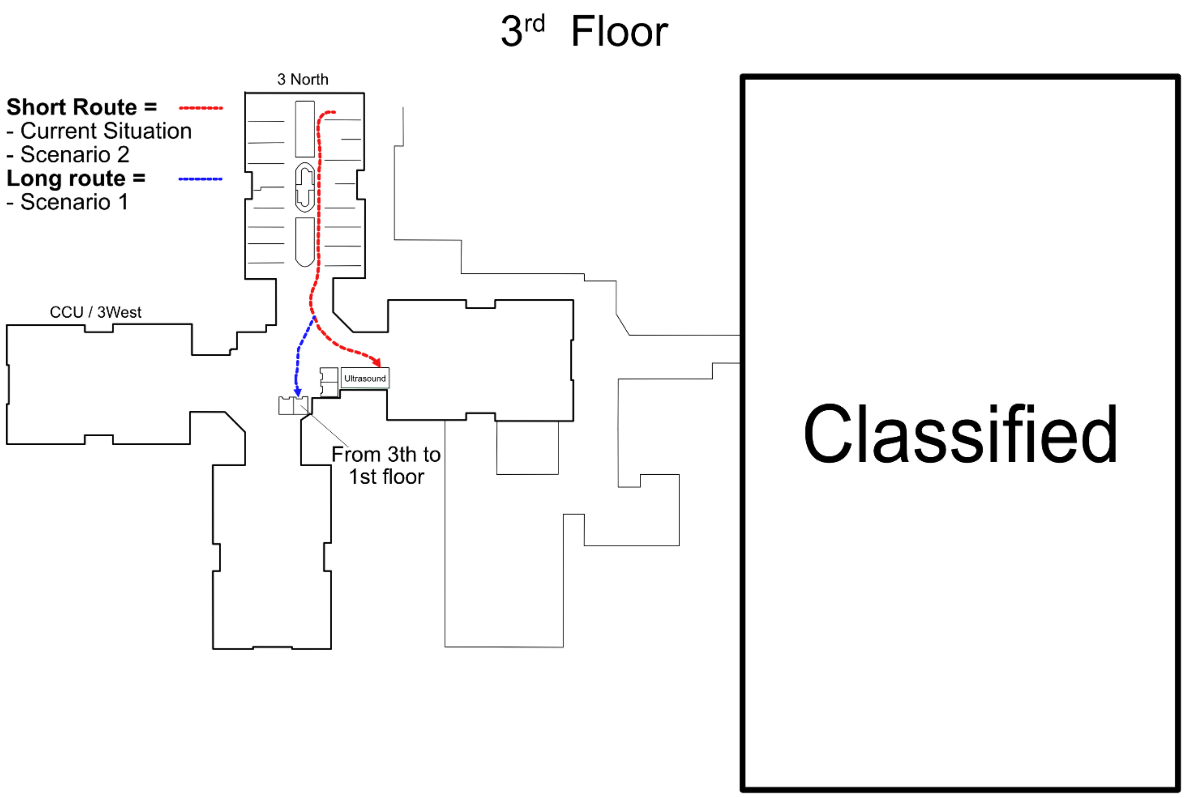


Figure 3 Map of 1st floor

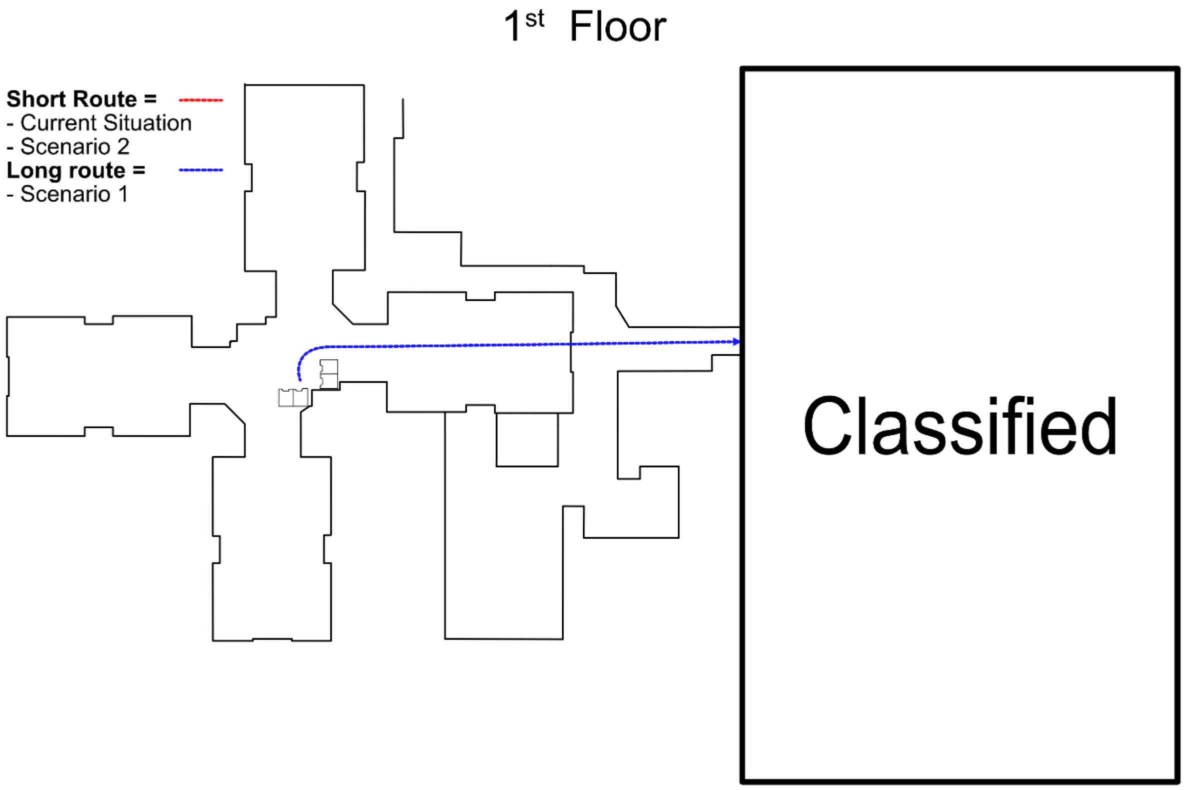
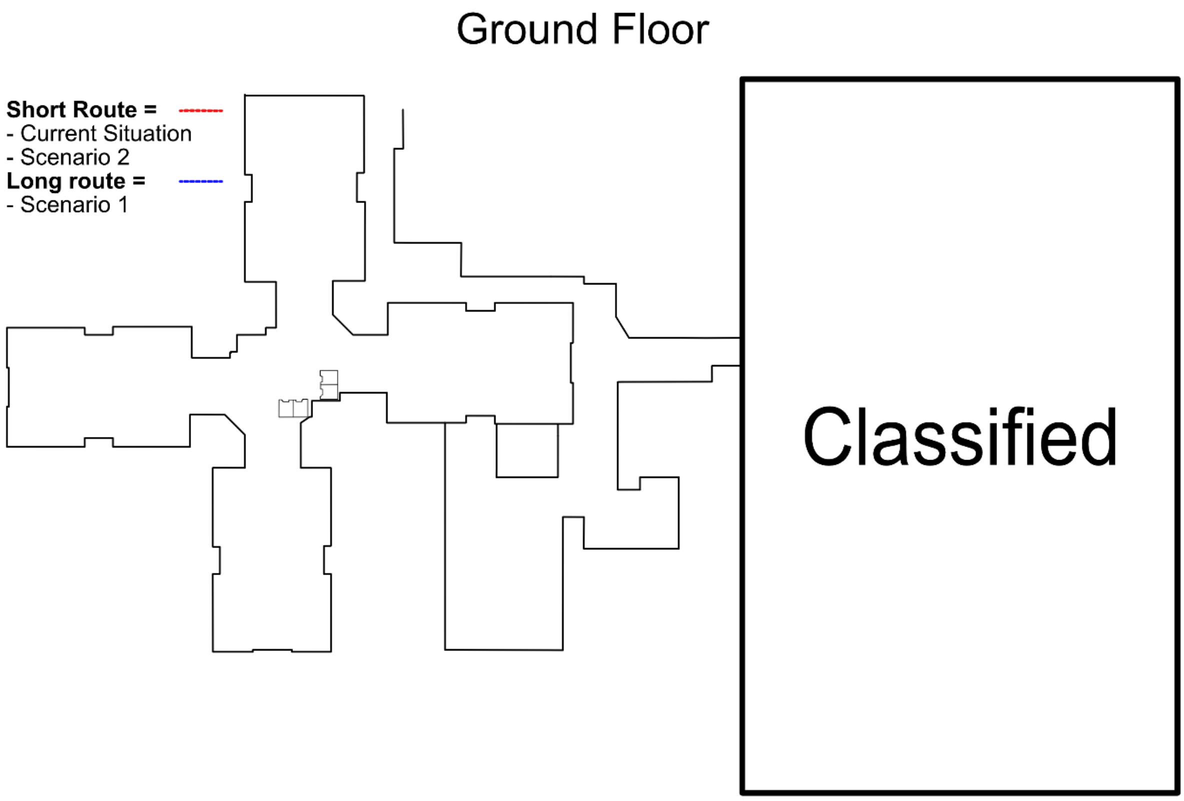


Figure 4 Map of Ground Floor



8.2 Interview Guideline

Grijs = Wat ik (ongeveer) ga vertellen voorafgaand aan een vraag, om context te schetsen en de vraag te introduceren.

OPNAME BEGINT

In mijn afstudeeropdracht ga ik 10 weken onderzoek doen naar het deelgebruik en apart gebruik van een fiets-/echokamer *Plattegrond/tekening erbij pakken* De CCU, kliniek en fiets-/echokamer zitten nu namelijk bij elkaar op verdieping 3. In fase 1 wordt er gebouwd voor een nieuwe plek voor de CCU en de fiets-/echokamer. In fase 2 wordt er gebouwd voor een nieuwe plek voor de kliniek. Fase 2 duurt echter ongeveer 4-5 jaar. In deze tijd zullen patiënten van de kliniek die naar de echokamer moeten, een flink langere route afleggen, wat waarschijnlijk een flinke belasting is. Het doel van de interviews is om in te gaan op de ervaring en mening van u als geïnterviewde m.b.t. het proces omtrent het gebruik van de fiets-echokamer.

Allereerst is het belangrijk om te herhalen dat uw deelname aan dit interview volledig anoniem is voor mijn eindverslag. Uw naam zal nooit worden gekoppeld aan uw antwoorden.

Zoals benoemd in de mail zal het geluid van dit interview worden opgenomen. Deze opname wordt met niemand gedeeld, en opgeslagen in een met wachtwoord beveiligde omgeving, waar alleen ik toegang tot heb. Zodra het onderzoek is afgelopen worden alle opnames verwijderd.

U gaat er nog steeds mee akkoord dat dit interview wordt opgenomen?

Als laatste is het belangrijk om te benoemen dat u vrijwillig deelneemt aan dit interview. Deelname aan dit interview biedt geen persoonlijk voor- of nadeel. Er bestaat geen goed of fout antwoord. Verder bent u vrij om het interview te verlaten en vragen niet te beantwoorden indien u zich daar niet prettig bij voelt.

Erkent u zojuist genoemde informatie?

Als ik klaar ben met mijn scriptie, ontvangt u van mij een kopie van het eindverslag indien u dit wilt.

Heeft u verder nog vragen voordat wij beginnen?

1. In uw werk, wat verstaat u onder zorg leveren van hoge kwaliteit?
2. Hoe ervaart u uw werkdruk op dit moment?
3. Wat is de rol van de logistieke aspecten van uw werk m.b.t. uw werkdruk?
4. In hoeverre zou het logistieke proces geoptimaliseerd kunnen worden? Bijvoorbeeld tbv mogelijke werkdruk.
5. Wanneer is een transfer van een patiënt in uw ogen goed verlopen?
6. Wat zouden er in uw mening nodig zijn om een transfer van een patiënt naar en van het echoapparaat goed te laten verlopen?

Momenteel wordt de echo-/fietskamer door de CCU en de Kliniek samen gebruikt.

7. Hoe ervaart u de huidige interactie met patiënten rondom het gebruik van de fiets en het echo apparaat?
8. In hoeverre beïnvloedt de transferroute deze interactie?
9. Wat vindt u het ideaalst aan de huidige manier waarop het echoapparaat in deelgebruik is tussen de CCU en de kliniek?

Er zijn in principe twee alternatieven om de bouwfases te overbruggen. Het is enerzijds mogelijk dat de CCU en de kliniek het echoapparaat samen blijven gebruiken, of dat ze beide hun eigen echoapparaat gaan gebruiken.

10. Stel de CCU en kliniek zouden elk hun eigen echoapparaat ter beschikking hebben. Welke voordelen zou u hierin zien?
11. Welke nadelen ziet u hierin?
12. Wat voor effect zou dit kunnen hebben op de interactie met uw patiënten?
13. Hoe zou de ideale transferroute er in uw ogen uitzien?
14. Wat zou er absoluut **niet** aanwezig moeten zijn op de transferroute?
15. Wat zou er absoluut **wel** aanwezig moeten zijn op de transferroute?

Afgelopen week heb ik (vergelijkbare) routes gelopen en gefilmd, om na te bootsen hoe de transferroute naar en van de fiets-/echokamer er nu uit ziet, en hoe de route er na/tijdens de verbouwing grofweg uit kan zien. Ik zou beide filmpjes graag aan u laten zien, om hier vervolgens enkele vragen over te stellen. Ik heb voor u ook pen & papier, mocht u notities willen maken.

*VIDEO's van routes (vergelijkbare routes) + papier & pen voor eventuele notities geïnterviewde

16. Waarin verschillen deze routes voor u het meest?
17. Wat voor invloed hebben deze verschillen op de interactie met u en uw patiënten?
18. Wat is het effect van beide routes op de snelheid en foutloosheid waarin u zorg kunt verlenen? Vervolgvraag: Welke andere effecten/consequenties ziet u hierin? Bijvoorbeeld dat patiënten langer moeten wachten dan afgesproken.

19. Wat is het effect van beide routes op de voldoening en tevredenheid die u uit uw werk haalt?
20. Wat is volgens u de beste optie, gezien alles wat we hebben besproken?
21. Zijn er dingen die we niet besproken hebben, waarvan u vind dat ze belangrijk zijn om te benoemen?

Hartelijk dank voor uw antwoorden!
OPNAME EINDIGEN
1. Wat vond u van het interview?

8.3 Calculations of the current route

See the table on the right.
The “3rd floor to elevator” column is taken from the measurements of the new route. A doorway was used to measure the current route. Walking from this doorway to the elevators made up 26% of the “3rd floor to elevator”. It takes about 17 seconds to walk from this doorway to the ultrasound location. Therefore the time of the “total current route” was measured as follows, we take row one as an example: 00:40.89 * (1-0.26) + 00:17.00 = 00:47.26.

8.4 Location Tags of Measurements

Round - outward	Round - return	Location Tag
1	4	3rd floor
2	2	Waiting at elevator
3	3	In elevator
4	1	1st floor

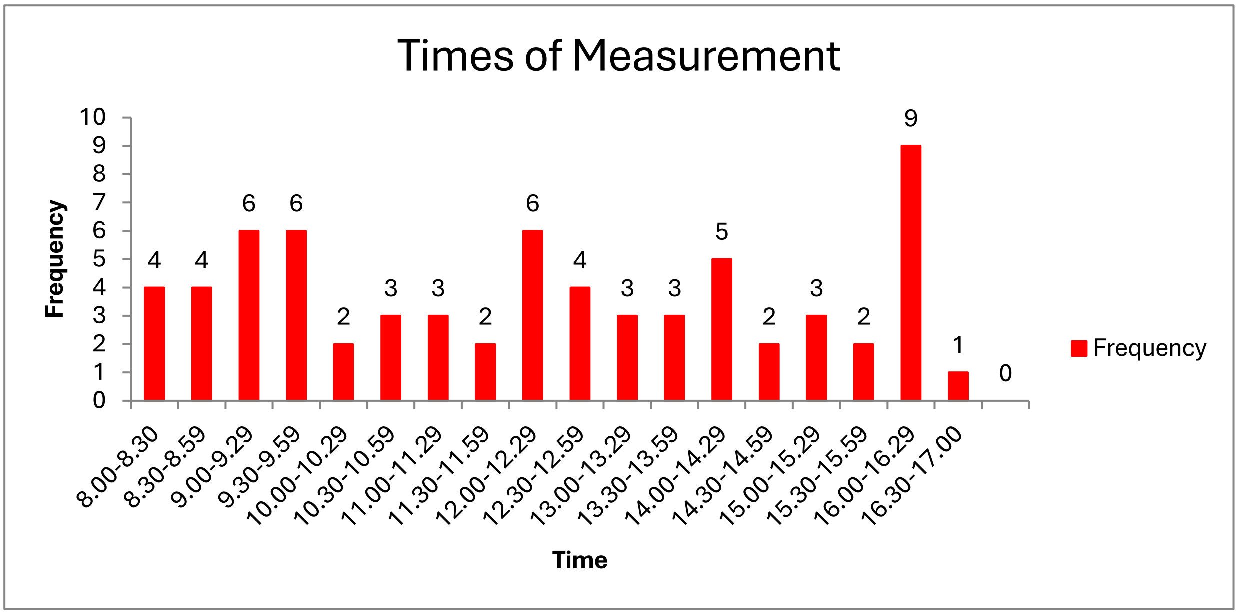
3rd floor to elevator	*3rd floor till corner	Corner to Ultrasoundroom	Total Current Route
00:40.89	00:30.26	00:17.00	00:47.26
00:41.82	00:30.95	00:17.00	00:47.95
00:42.31	00:31.31	00:17.00	00:48.31
00:44.43	00:32.88	00:17.00	00:49.88
00:45.32	00:33.54	00:17.00	00:50.54
00:46.17	00:34.17	00:17.00	00:51.17
00:38.14	00:28.22	00:17.00	00:45.22
00:48.53	00:35.91	00:17.00	00:52.91
00:35.15	00:26.01	00:17.00	00:43.01
00:39.60	00:29.30	00:17.00	00:46.30
00:35.86	00:26.54	00:17.00	00:43.54
00:41.45	00:30.67	00:17.00	00:47.67
00:46.22	00:34.20	00:17.00	00:51.20
00:50.96	00:37.71	00:17.00	00:54.71
00:42.29	00:31.29	00:17.00	00:48.29
00:41.32	00:30.58	00:17.00	00:47.58
00:48.56	00:35.93	00:17.00	00:52.93
00:52.15	00:38.59	00:17.00	00:55.59
00:44.24	00:32.74	00:17.00	00:49.74
00:44.29	00:32.77	00:17.00	00:49.77
00:44.20	00:32.71	00:17.00	00:49.71
00:44.56	00:32.97	00:17.00	00:49.97
00:39.87	00:29.50	00:17.00	00:46.50
00:40.57	00:30.02	00:17.00	00:47.02
00:45.83	00:33.91	00:17.00	00:50.91
00:42.65	00:31.56	00:17.00	00:48.56
00:42.22	00:31.24	00:17.00	00:48.24
00:42.02	00:31.09	00:17.00	00:48.09
00:40.15	00:29.71	00:17.00	00:46.71
00:42.53	00:31.47	00:17.00	00:48.47
00:36.44	00:26.97	00:17.00	00:43.97
00:43.56	00:32.23	00:17.00	00:49.23
00:41.12	00:30.43	00:17.00	00:47.43
00:43.22	00:31.98	00:17.00	00:48.98
00:39.83	00:29.47	00:17.00	00:46.47
00:42.09	00:31.15	00:17.00	00:48.15
00:42.10	00:31.15	00:17.00	00:48.15
00:53.61	00:39.67	00:17.00	00:56.67
00:40.53	00:29.99	00:17.00	00:46.99
00:40.67	00:30.10	00:17.00	00:47.10
00:41.28	00:30.55	00:17.00	00:47.55
00:42.12	00:31.17	00:17.00	00:48.17
00:45.62	00:33.76	00:17.00	00:50.76
00:50.25	00:37.18	00:17.00	00:54.18
00:41.60	00:30.78	00:17.00	00:47.78
00:39.25	00:29.05	00:17.00	00:46.04
00:45.19	00:33.44	00:17.00	00:50.44
00:40.85	00:30.23	00:17.00	00:47.23
00:42.79	00:31.66	00:17.00	00:48.66
00:42.79	00:31.66	00:17.00	00:48.66
00:43.50	00:32.19	00:17.00	00:49.19
00:43.17	00:31.95	00:17.00	00:48.95
00:41.69	00:30.85	00:17.00	00:47.85
00:42.81	00:31.68	00:17.00	00:48.68
00:43.51	00:32.20	00:17.00	00:49.20
00:43.11	00:31.90	00:17.00	00:48.90
00:39.44	00:29.19	00:17.00	00:46.19
00:49.26	00:36.45	00:17.00	00:53.45
00:44.06	00:32.60	00:17.00	00:49.60
00:49.55	00:36.67	00:17.00	00:53.67
00:47.01	00:34.79	00:17.00	00:51.79
00:45.36	00:33.57	00:17.00	00:50.57
00:44.47	00:32.91	00:17.00	00:49.91
00:44.83	00:33.17	00:17.00	00:50.17
00:37.67	00:27.88	00:17.00	00:44.88
00:39.35	00:29.12	00:17.00	00:46.12
00:40.22	00:29.76	00:17.00	00:46.76
01:04.35	00:47.62	00:17.00	01:04.62

8.5 All measurements

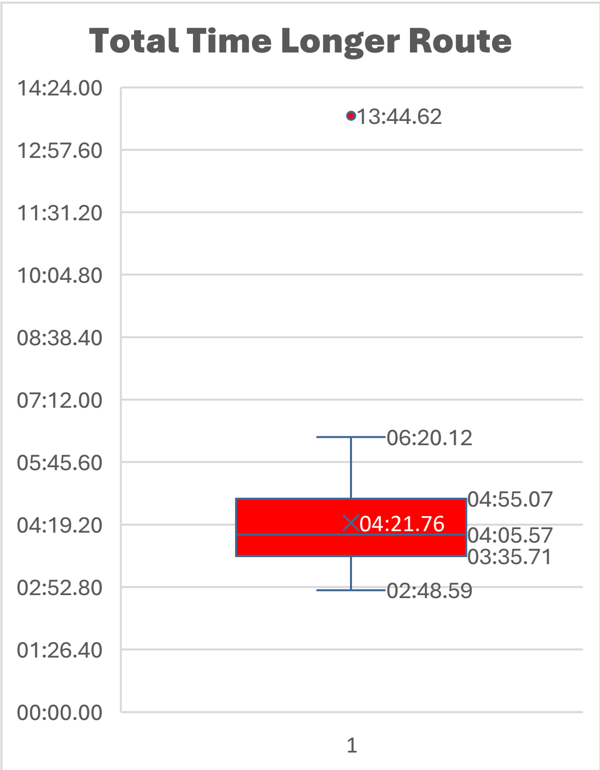
Timings Route to new building (heenroute) - in minutes - minutes:seconds.milliseconds								Timings in new building - minutes:seconds.milliseconds			
ID	Date	Time of Measurement	Total Time Measurement	3rd floor	Waiting at elevator	In elevator	1st floor	Walking 28m	Waiting 2nd Elevator	In 2nd elevator	Total Time New Route
1	28-Apr	12:28	02:31.54	00:40.89	00:28.64	00:12.88	01:09.13	00:21.00	00:28.64	00:08.88	03:30.06
2	28-Apr	12:35	02:48.81	00:41.82	00:43.96	00:13.46	01:09.57	00:21.00	00:43.96	00:09.46	04:03.23
3	28-Apr	16:02	03:18.20	00:42.31	01:10.10	00:13.17	01:12.62	00:21.00	01:10.10	00:09.17	04:58.47
4	28-Apr	16:21	02:23.02	00:44.43	00:19.59	00:12.44	01:06.56	00:21.00	00:19.59	00:08.44	03:12.05
5	29-Apr	12:22	03:18.74	00:45.32	01:08.66	00:13.05	01:11.71	00:21.00	01:08.66	00:09.05	04:57.45
6	29-Apr	12:32	03:23.27	00:46.17	01:16.87	00:12.81	01:07.42	00:21.00	01:16.87	00:08.81	05:09.95
7	29-Apr	15:17	03:17.23	00:38.14	01:23.86	00:13.37	01:01.86	00:21.00	01:23.86	00:09.37	05:11.46
8	29-Apr	15:28	03:01.92	00:48.53	01:04.75	00:13.38	00:55.26	00:21.00	01:04.75	00:09.38	04:37.05
9	30-Apr	09:07	02:08.19	00:35.15	00:22.54	00:13.14	00:57.36	00:21.00	00:22.54	00:09.14	03:00.87
10	30-Apr	09:13	03:00.76	00:39.60	01:12.81	00:13.09	00:55.26	00:21.00	01:12.81	00:09.09	04:43.66
11	30-Apr	14:27	02:27.12	00:35.86	00:33.28	00:12.72	01:05.26	00:21.00	00:33.28	00:08.72	03:30.12
12	30-Apr	14:37	03:17.65	00:41.45	01:22.77	00:13.47	00:59.96	00:21.00	01:22.77	00:09.47	05:10.89
13	01-May	09:34	03:02.33	00:46.22	00:56.98	00:12.97	01:06.16	00:21.00	00:56.98	00:08.97	04:29.28
14	01-May	09:42	03:32.10	00:50.96	01:23.17	00:14.12	01:03.85	00:21.00	01:23.17	00:10.12	05:26.39
15	01-May	12:26	02:33.90	00:42.29	00:31.66	00:13.10	01:06.85	00:21.00	00:31.66	00:09.10	03:35.66
16	01-May	12:35	02:18.43	00:41.32	00:13.00	00:20.06	01:04.05	00:21.00	00:13.00	00:16.06	03:08.49
17	02-May	10:52	02:40.46	00:48.56	00:32.91	00:13.03	01:05.96	00:21.00	00:32.91	00:09.03	03:43.40
18	02-May	11:00	03:01.35	00:52.15	00:52.41	00:12.69	01:04.10	00:21.00	00:52.41	00:08.69	04:23.45
19	02-May	14:04	02:41.34	00:44.24	00:37.51	00:15.03	01:04.56	00:21.00	00:37.51	00:11.03	03:50.88
20	02-May	14:10	02:33.60	00:44.29	00:32.17	00:13.21	01:03.93	00:21.00	00:32.17	00:09.21	03:35.98
21	06-May	14:58	02:36.03	00:44.20	00:33.15	00:12.87	01:05.81	00:21.00	00:33.15	00:08.87	03:39.05
22	06-May	15:04	03:08.04	00:44.56	01:07.60	00:12.12	01:03.76	00:21.00	01:07.60	00:08.12	04:44.76
23	06-May	16:09	02:27.28	00:39.87	00:22.96	00:14.00	01:10.45	00:21.00	00:22.96	00:10.00	03:21.24
24	06-May	16:15	03:54.14	00:40.57	01:55.77	00:13.21	01:04.59	00:21.00	01:55.77	00:09.21	06:20.12
25	07-May	10:47	02:24.10	00:45.83	00:21.15	00:13.09	01:04.03	00:21.00	00:21.15	00:09.09	03:15.34
26	07-May	10:52	02:47.47	00:42.65	00:51.22	00:12.82	01:00.78	00:21.00	00:51.22	00:08.82	04:08.51
27	07-May	16:26	02:34.47	00:42.22	00:32.56	00:12.50	01:07.19	00:21.00	00:32.56	00:08.50	03:36.53
28	07-May	16:32	02:19.11	00:42.02	00:22.96	00:12.61	01:01.52	00:21.00	00:22.96	00:08.61	03:11.68
29	08-May	11:47	02:54.24	00:40.15	00:56.21	00:13.01	01:04.87	00:21.00	00:56.21	00:09.01	04:20.46
30	08-May	11:55	03:37.66	00:42.53	01:37.25	00:12.97	01:04.91	00:21.00	01:37.25	00:08.97	05:44.88
31	08-May	16:05	02:07.73	00:36.44	00:11.44	00:12.42	01:07.43	00:21.00	00:11.44	00:08.42	02:48.59
32	08-May	16:12	02:33.25	00:43.56	00:35.67	00:12.75	01:01.27	00:21.00	00:35.67	00:08.75	03:38.67
33	09-May	08:48	03:43.12	00:41.12	01:45.04	00:13.02	01:03.94	00:21.00	01:45.04	00:09.02	05:58.18
34	09-May	08:54	02:54.41	00:43.22	00:55.02	00:12.84	01:03.33	00:21.00	00:55.02	00:08.84	04:19.27
35	09-May	12:19	02:40.69	00:39.83	00:43.63	00:12.83	01:04.40	00:21.00	00:43.63	00:08.83	03:54.15
36	09-May	12:25	02:52.73	00:42.09	00:54.52	00:12.70	01:03.42	00:21.00	00:54.52	00:08.70	04:16.95
37	12-May	09:17	02:31.71	00:42.10	00:34.52	00:13.91	01:01.18	00:21.00	00:34.52	00:09.91	03:37.14
38	12-May	09:23	03:21.38	00:53.61	01:12.11	00:13.49	01:02.17	00:21.00	01:12.11	00:09.49	05:03.98
39	12-May	16:05	02:50.46	00:40.53	00:12.20	00:44.90	01:12.83	00:21.00	00:12.20	00:40.90	04:04.56
40	12-May	16:11	02:22.27	00:40.67	00:28.59	00:12.65	01:00.36	00:21.00	00:28.59	00:08.65	03:20.51
41	13-May	09:14	02:49.57	00:41.28	00:49.98	00:11.85	01:06.46	00:21.00	00:49.98	00:07.85	04:08.40
42	13-May	09:10	02:16.24	00:42.12	00:19.84	00:12.94	01:01.34	00:21.00	00:19.84	00:08.94	03:06.02
43	13-May	14:05	02:31.78	00:45.62	00:21.39	00:12.50	01:12.27	00:21.00	00:21.39	00:08.50	03:22.67
44	13-May	14:15	03:48.56	00:50.25	00:44.95	01:08.64	01:04.72	00:21.00	00:44.95	01:04.64	05:59.15
45	14-May	09:53	02:35.45	00:41.60	00:32.12	00:12.59	01:09.14	00:21.00	00:32.12	00:08.59	03:37.16
46	14-May	09:59	02:59.03	00:39.25	00:57.75	00:11.95	01:10.08	00:21.00	00:57.75	00:07.95	04:25.73
47	14-May	13:20	03:23.69	00:45.19	01:23.68	00:12.62	01:02.20	00:21.00	01:23.68	00:08.62	05:16.99
48	14-May	13:53	07:33.91	00:40.85	05:41.28	00:12.43	00:59.35	00:21.00	05:41.28	00:08.43	13:44.62
49	15-May	10:15	02:28.31	00:42.79	00:26.83	00:11.99	01:06.70	00:21.00	00:26.83	00:07.99	03:24.13
50	15-May	10:25	02:58.13	00:42.79	01:01.90	00:11.64	01:01.80	00:21.00	01:01.90	00:07.64	04:28.67
51	15-May	12:35	02:39.41	00:43.50	00:35.94	00:12.77	01:07.20	00:21.00	00:35.94	00:08.77	03:45.12
52	15-May	12:50	02:43.49	00:43.17	00:49.84	00:12.81	00:57.67	00:21.00	00:49.84	00:08.81	04:03.14
53	16-May	09:40	02:38.26	00:41.69	00:12.05	00:39.78	01:04.74	00:21.00	00:12.05	00:35.78	03:47.09
54	16-May	09:46	03:14.02	00:42.81	01:14.39	00:13.90	01:02.92	00:21.00	01:14.39	00:09.90	04:59.31
55	16-May	13:07	03:45.09	00:43.51	01:42.12	00:12.53	01:06.93	00:21.00	01:42.12	00:08.53	05:56.74
56	16-May	13:12	02:27.37	00:43.11	00:30.32	00:12.73	01:01.21	00:21.00	00:30.32	00:08.73	03:27.42
57	19-May	08:50	03:23.50	00:39.44	01:29.75	00:12.87	01:01.44	00:21.00	01:29.75	00:08.87	05:23.12
58	19-May	08:55	02:47.33	00:49.26	00:45.07	00:12.07	01:00.93	00:21.00	00:45.07	00:08.07	04:01.47
59	19-May	15:41	02:32.95	00:44.06	00:33.37	00:12.55	01:02.97	00:21.00	00:33.37	00:08.55	03:35.87
60	19-May	15:47	02:57.17	00:49.55	00:55.08	00:12.31	01:00.23	00:21.00	00:55.08	00:08.31	04:21.56
61	20-May	08:24	02:29.87	00:47.01	00:29.65	00:13.16	01:00.05	00:21.00	00:29.65	00:09.16	03:29.68
62	20-May	08:29	02:54.92	00:45.36	00:42.84	00:11.83	01:14.89	00:21.00	00:42.84	00:07.83	04:06.59
63	20-May	13:42	03:34.37	00:44.47	01:32.61	00:13.91	01:03.38	00:21.00	01:32.61	00:09.91	05:37.89
64	20-May	13:50	03:09.25	00:44.83	01:07.50	00:14.18	01:02.74	00:21.00	01:07.50	00:10.18	04:47.93
65	21-May	08:20	03:04.85	00:37.67	01:13.09	00:12.97	01:01.12	00:21.00	01:13.09	00:08.97	04:47.91
66	21-May	08:26	03:01.31	00:39.35	01:08.50	00:12.60	01:00.86	00:21.00	01:08.50	00:08.60	04:39.41
67	21-May	11:08	02:11.17	00:40.22	00:13.20	00:12.40	01:05.35	00:21.00	00:13.20	00:08.40	02:53.77
68	21-May	11:14	02:34.84	01:04.35	00:33.75	00:13.44	00:43.30	00:21.00	00:33.75	00:09.44	03:39.03

The part in the new building also involves an elevator. The waiting time of the elevators in round two are taken for this second elevator. It is namely not possible to determine if the waiting times of this new elevator will be longer or shorter than the waiting times for the current elevator. To calculate the time spent in this new elevator, the duration of the time spent in the current elevator is firstly deducted by four seconds and then added to the total time. This elevator ride namely involves one drop in floor levels, whereas the measured elevator ride involves two drops in floor levels. It takes the elevator four seconds to go down one floor level.
It also involves walking 28 meters to the elevators. The video used in the interviews mimicked this, and this showed that walking 28 meters with a wheelchair can take 21 seconds.

8.6 Time of measurements

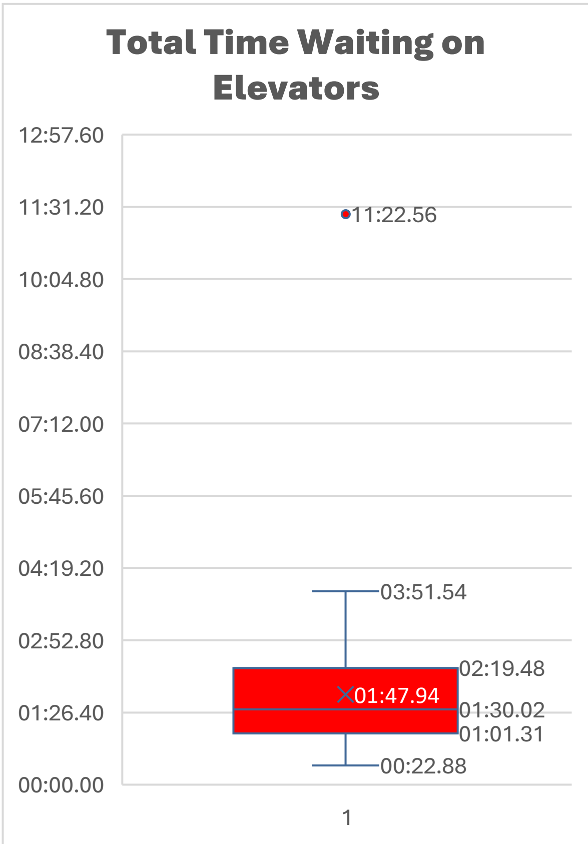


8.7 Boxplot of measurements



This boxplot shows the average time it takes to walk from the patient rooms at 3North to the new location of the ultrasound room, or the other way around. Note that nurses have this distance four times for a single transfer: bring a patient to the research, walk back alone, walk to the research alone, walk back with the patient.

8.8 Boxplot of waiting on elevator



This boxplot shows how much time is spent on average to wait for the elevators when walking this distance once.

8.9 Average time spent on longer transfer over five years

Year	Total Amount of Times the route is walked for a research	Averag Total Hours spent on longer transfer per year (hours * 4, every transfer requires walking the route 4 times) =
2025	*994*	*289.0993778*
2024	1573	457.4983111
2023	1479	430.1589333
2022	1520	442.0835556
2021	1595	463.8968889
2020	1474	428.7047111
Average of 2020 -2024	1528.2	444.46848
Average_Total Hours spent on longer transfer over 5 years		**2222.34**

This table shows that from 2020 to 2024 a total of 2,222.34 hours would have been spent on transfers if they had the longer route. Note that 2025 is not used since this year was not completed. The COVID years were deemed representative since this care continued to be delivered at the same rate, given that it is vital care.

8.10 Average time spent on shorter transfer over five years

Year	Total Amount of Times the route is walked for a research	Averag Total Hours spent on shorter transfer per year (hours * 4, every transfer requires walking the route 4 times) =
2025	*994*	*54.26135556*
2024	1573	85.86832222
2023	1479	80.73696667
2022	1520	82.97511111
2021	1595	87.06927778
2020	1474	80.46402222
Average of 2020 -2024	1528.2	83.42274
Average_Total Hours spent on shorter transfer over 5 years		**417.11**

This table shows that from 2020 to 2024 a total of 417.11 hours is spent on the shorter route.

8.11 Transfer costs if all are done by nurses

For the gross monthly wages, the median of the scale was used, since a precise average was not identified. Both this and the net deployable hours were taken from the collective labor agreement of hospitals. The percentages for vacation pay and compulsory employee costs are percentages that are commonly used to calculate costs of employment.

Calculation of Costs difference			
median of gross monthly wages for nurses	€ 3,593.00		
	x 12		
Yearly gross wages for nurses		€ 43,116.00	
Vacation pay	+8%		
Compulsory employee costs for employer (zorglasten, NL)	+30%		
employer		€ 60,534.86	
Net deployable hours	1468		
Hourly costs (rounded)		€ 41.24	
	x 2222.34 hours		
Total costs of longer transfer			€ 91,641.14
	x 417.11 hours		
Total costs of shorter transfer			€ 17,200.22
Over a period of 5 years, the longer route is more expensive by...			€ 74,440.92

8.12 Transfer costs including assumptions

The first table below shows the assumptions that were done based on what was mentioned in the interviews and other conversations. Which are: for 10% of the researches the operator has to move the ultrasound device; of the other 90%, 60% is done by patients in wheelchairs, 30% in a bed, and 10% by volunteers. It was also said that from one department 50% of the people walk to the ultrasound room themselves. For the longer route it was assumed that no patients will walk to the ultrasound room themselves (based on the argumentation given in the interviews).

Calculation of Longer route with assumptions			
median of gross monthly wages for **nurses**	€ 3,593.00		
	x 12		
Yearly gross wages for nurses		€ 43,116.00	
Vacation pay	+8%		
Compulsory employee costs for employer (zorglasten, NL)	+30%		
employer		€ 60,534.86	
Net deployable hours	1468		
Hourly costs **nurses** (rounded)		€ 41.24	
90% of the time patients are transfered			
Of which 60% by nurses with patients in wheelchairs...	x 2222.34 hours x 90% x 60%		€ 49,486.22
and 30% by nurses with patients in bed, thus 2 nurses needed ...	x 2222.34 hours x 90% x 30% x 2		€ 49,486.22
and 10% by volunteers.	x 2222.34 hours x 90% x 0.10 x 0		€ -
median of gross monthly wages for **operators**	€ 4,346.00		
	x 12		
		€ 52,152.00	
Vacation pay	+8%		
Compulsory employee costs for employer (zorglasten, NL)	+30%		
		€ 73,221.41	
Net deployable hours	1468		
Hourly costs **operators** (rounded)		€ 49.88	
10% of the timeoperators have to transfer	x 2222.34 x 10%		€ 11,084.68
Total costs of longer transfer			**€ 110,057.11**

Calculation of shorter route with assumptions			
median of gross monthly wages for **nurses**	€ 3,593.00		
	x 12		
Yearly gross wages for nurses		€ 43,116.00	
Vacation pay	+8%		
Compulsory employee costs for employer (zorglasten, NL)	+30%		
Annual costs per nurse for employer		€ 60,534.86	
Net deployable hours	1468		
Hourly costs **nurses** (rounded)		€ 41.24	
90% of the time research is done at the ultrasound room...			
of which patients walk themselves 25% of the time,...	0 x 417.11 hours x 90% x 25%		€ -
and 45% (0.75x0.6) is transferred by nurses with patients in wheelchairs...	x 417.11 hours x 90% x 45%		€ 6,966.09
and 22.5% (0.75x0.3) by nurses with patients in bed, thus 2 nurses needed ...	x 417.11 hours x 90% x 22.5% x 2		€ 6,966.09
and 7.5% (0.75x0.1) by volunteers.	0 x 417.11 hours x 90% x 7.5%		€ -
median of gross monthly wages for **operators**	€ 4,346.00		
	x 12		
		€ 52,152.00	
Vacation pay	+8%		
Compulsory employee costs for employer (zorglasten, NL)	+30%		
		€ 73,221.41	
Net deployable hours	1468		
Hourly costs **operators** (rounded)		€ 49.88	
10% of the timeoperators have to transfer	x 2222.34 x 10%		€ 2,080.49
Total costs of shorter transfer			**€ 16,012.67**

The second table also works with the same assumptions, however this time the portion of the patients that can walk themselves was included. This did require changes to the percentages, of which the calculations are shown in between brackets in this table.

	€ 110,057.11
	€ 16,012.67
Over a period of 5 years, the longer route (with more assumptions) is more expensive by ...	**€ 94,044.44**

Hours spent extra on longer transfer over 5 years	1805.23	
	/5	
Hours spent extra on longer transfer per year		361.0457
Net deployable hours per year	1468	
FTE spent extra per year		0.245944

1573	524.3333333	€	26,152.88
1479	493	€	24,590.02
1520	506.6666667	€	25,271.69
1595	531.6666667	€	26,518.65
1474	491.3333333	€	24,506.89
1528.2	509.4	€	25,408.03
	Costs of extra operator for research over 5 years	€	127,040.14

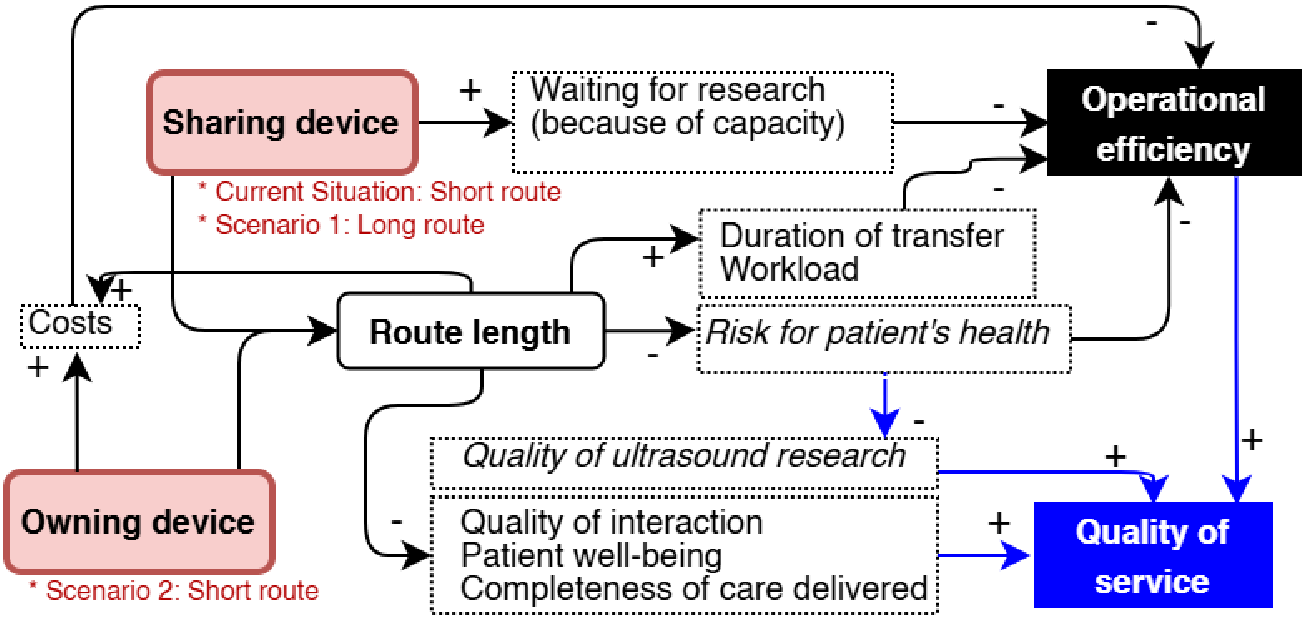
In the interview transcripts was found that the average ultrasound research lasts 20 minutes. The second scenario requires an additional operator.

This leads to an additional €127,040.14 costs of an additional operator over 5 years. The purchasing costs were found to be €153,725. These are depreciated over 7 years: €21,960.71 a year. Together with the short route of €8,006.36 (€16,012.67/2 because only 3North will walk to the new ultrasound machine) and the operator costs, this makes that scenario 2 cost: €21,960.71 * 5 + €8,006.36 + €127,040.14 = **€244,850.05**. When taking the costs of the transfer route for scenario 1, this is **€134,792.94** more than scenario 1 over 5 years (€244,850.05-€110,057.11). However, scenario 1 also involves other costs, like additional wheelchairs, costs of calamities, reputation damage, potential loss of nursing staff. The quantity of these could not be identified in this research period.

The following conclusion could be drawn. If the department is will to invest **€26,958.59** a year to avoid all the negative potential effects on operational efficiency and quality of care, then the advice would be to purchase the second device.

8.13 Simplified overview of results

The arrows indicate relationships. In front and after every arrow is a + or - sign. These should be interpreted as positive or negative relationships. The sign in front of a quadrant represents its relationship with the node before. The sign after a factor represents its relationship with the next node. In a positive relationship, the next node increases if the former increases, and vice versa. For example, the longer the **route** (**length**), the higher the **workload**. In a negative relationship, the next node decreases if the former increases, and vice versa. For example, higher **costs** lead to less **operational efficiency**. Note that sharing a device can have both a long and a short route, whereas owning a device only has a short route. Additionally, the "quality of ultrasound research" is affected by the "risk for patient's health".



8.14 Detailed overview of result

The arrows indicate relationships between the nodes. Besides every arrow is a + or -. These should be interpreted as positive or negative relationships. In a positive relationship, the next node increases if the former increases, and vice versa. For example, the longer the **route (length)**, the more **time a nurse is absent from** the **department**. In a negative relationship, the next node decreases if the former increases, and vice versa. For example, the longer the **route (length)** the higher the **transfer costs**. Note that sharing a device can have both a long and a short route, whereas owning a device only has a short route.