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Funding the online Doctor

Recommendation for the funding model of Spreekuur

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Industrial Engineering and Management

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Preface

This thesis is the part of my bachelor Industrial Engineering and Management at the University of Twente. I performed my research at Topicus, with as main goal to create a funding model for Spreekuur.

Firstly, I would like to thank my colleagues at Topicus for their contribution to this thesis. Even though I could not go to the office due to the coronavirus, I still had weekly contact with them and they were always able to share information and help me with my process. In particular, I want to thank Stefan ten Vergert and Annoek Linthorst for giving me the opportunity to do this thesis. During our meetings, I learned a lot about Topicus and Spreekuur, which gave me a better understanding of the situation. Also, their personal guidance and opinions helped me to improve on a personal level.

Secondly, I want to thank my supervisor at the University of Twente, Reinoud Joosten, who helped me with writing this report. His feedback helped me to progress and go to the next step. I also want to thank Abhishta Abhishta for being my second supervisor.

Lastly, I would like to thank my girlfriend Meike, for her support during my bachelor study. She motivated me to stay on track with my research. I also want to thank my parents Wibo and Miranda, my brother Gijs and his girlfriend Amber, for their motivational support. Furthermore, I want to thank my friends for their support.

Max Kloosterman

Heeten, July 2020

Management summary

Introduction

Topicus creates innovative software platforms to connect people, users and those who work in education, healthcare, or financial services. They want that everyone always has an overview and insight into their situation and can make their own decisions. One of their new products is called Spreekuur. This is an application that makes online consultations between patients and doctor possible. Also, a part of the work is moved to the patient, which should save the general practitioner time.

Currently, there is no funding model for Spreekuur. This makes it unclear for general practitioners whether they can generate more income and reduce costs with Spreekuur. Therefore, the research question became: *What requirements should the funding model for Spreekuur have such that it provides relevant information for primary care providers, taken different scenarios into account?*

Primary healthcare in the Netherlands

First, an overview of the current situation within primary healthcare is explained. In the Netherlands, the general practitioner is the first person a patient can go to with a health complaint. This care process can be executed in different forms. Physical consultations, telephone consultations and visit consultations are the most common forms of consultation, but different forms of digital consultation experience an increase in usage as well. The execution of consultations is one of the main income sources of a general practitioner. The tariff that is funded to the general practice for a consultation depends on the duration. Also, the maximum tariff for a visit consultation is higher than that of the other forms of consultation. Another main income source is the registration fee of patients. Health insurance companies pay the tariff of all registered patients to general practices. The amount of funding depends on the age of the patient and the homing location.

Income

Both income sources are related to Spreekuur because patients can use Spreekuur as a form of digital consultation, and the registration fee of patients can be higher when a general practice can claim one of the result rewards. These are awarded for general practices that increase the accessibility or quality of primary healthcare. With the implementation of Spreekuur, the general practice offers a higher service and better accessibility for their patients. Furthermore, in shrinking regions, the implementation of Spreekuur can stimulate practitioner care in the area. Furthermore, general practices can make agreements with a health insurance company about funding or rewarding the use of eHealth. A policy rule is set up by the NZa, which makes it possible to experiment with innovations, like Spreekuur, at a small scale for a maximum period of three years. After this period, Spreekuur should be cost-efficient as well, which is not possible with only an income increase, generated by the result rewards.

Costs

Therefore, Spreekuur must cut the costs of the general practice. Mainly the employee costs and housing location costs because these are the highest costs that can be influenced by the implementation of Spreekuur. Employee costs can be decreased when the consultations with Spreekuur have a shorter duration than the duration of the other forms of consultation. Another option to decrease employee costs is obtained when doctor’s assistants can do consultations with Spreekuur because they are less expensive than general practitioners. Whereas the housing location costs can be decreased when the number of physical consultations is fewer after the implementation of Spreekuur.

Analysing methods

A framework of the most common statistical analysing methods in a medical context helps by selecting the best analysing method. To ensure valid results from the tests, the data sets must meet certain assumptions. Therefore, situations have been outlined, regarding the data of the time-efficiency and the decrease of patient's visits, and the corresponding analysing methods are selected.

To decrease employee costs, the application must be more time-efficient than other consultation forms. To analyse this, I recommend using the Mann-Whitney U test, which compares the mean of two populations with two random independent samples.

To decrease the housing locations costs, the application must lead to fewer consultations at the general practice. For physical consultation, the patient comes to the general practice, where a certain number of rooms must be rented. To analyse a decrease in the number of physical consultations, I recommend using the dependent t-test, which tests on the mean difference of two paired samples.

Furthermore, it has been explained how these methods, and other common methods, can be used in a medical context. As a result, this framework of statistical methods can also be applied to analyse other products, functions, or systems in the future.

Contents

Reader's guide

This reader's guide provides the reader a better understanding of this project, giving a short explanation of the content of each chapter.

Chapter 1

The project starts with an introduction. This includes a description of Topicus and the problem context. To solve the problem, a problem-solving approach is constructed, with corresponding research design. The chapter ends with the deliverables to Topicus.

Chapter 2

This chapter provides a general overview of the current situation in primary healthcare, which is the sector Topicus has created Spreekuur for. Giving information about what happens at most general practices, which forms of care processes there are and how patients go through these care process. With information about the current situation, the reader gets a better understanding of how Spreekuur may fit into primary healthcare.

Chapter 3

Chapter 3 outlines the financial situation of primary healthcare. This includes funding of primary healthcare, which is separated into three different segments and a performance segment. This covers the incomes of general practices and general practice centres, and performance bonuses and funding for innovations regarding digital healthcare. In addition to that, this chapter also covers the main costs that general practices and general practices centres have.

Chapter 4

This chapter outlines the developments and innovations regarding digitalisation within primary healthcare, describing how a more digital work environment can lower the workload of care providers. This is necessary because they get more responsibility and more healthcare-related questions from the population. Furthermore, the chapter further explains how Spreekuur is part of the digital developments, and which changes must occur at a general practice to make Spreekuur cost-efficient.

Chapter 5

Chapter 5 covers the different efficiency analysing methods found in the literature. Providing a framework of the most used analysing methods in a medical context. The methods that compare the difference in means of two groups are explained in more detail.

Chapter 6

This chapter outlines the analyses of the processes at the general practice centre with Spreekuur. Scenarios for the patient's visits and the time-efficiency of Spreekuur were constructed, to measure the processes with corresponding statistical analysing methods. Results from the tests were analysed and validated. These results indicate the efficiency of Spreekuur for general practices.

Chapter 7

This chapter outlines the main findings of this thesis. In the conclusion section the answer to the main research question is drawn. Then, recommendations for Topicus about the funding and cost-efficiency of Spreekuur are given. After that, the shortcomings of this thesis are outlined.

1. Introduction

Topicus is the company for which I conduct this project. They create innovative software platforms. In this way, Topicus connects people, users and those who work in education, healthcare, or financial services. They want that everyone always has an overview and insight into their situation and can make their own choices.

During my bachelor project by Topicus, I work in the customer advisor and implementation team from the care division. They are the VIPLIVE customer team and link between the development teams and the healthcare organizations to which they deliver the system. Their package consists roughly of the following components: declarations, cooperation, and insight.

For my bachelor project, I work with one of their new products called Spreekuur. Spreekuur is an application, developed by DigiDok and Topicus, that makes online consultations between patient and doctor possible. With the application, a part of the work is shifted from the care providers to the patient. This should help care providers by referring less urgent patients, so they have more time to help complex and highly urgent patients. Also, a part of the work is moved to the patient, which should save the general practitioner time.

1.1 Problem identification

Innovations and developments also bring along new changes with them, like financial and workload changes. For a company, it is useful to have a prediction of the future, and how this may affect products. This is also the case for Topicus. They develop IT platforms for society. One of their divisions is Healthcare. The division Healthcare can be divided into several sectors, one of them is primary healthcare. Traditionally primary healthcare focusses on curing people, which is most of the time on an appointment. However, primary healthcare gets more and more care aspects as well. This means general practitioners they become more proactive, accompanying patients during the care process. Lately, developments show a trend towards prevention of illness (Calculus, 2020). All these developments in primary healthcare also influence funding. Therefore, I will investigate the financial flows in primary care in this thesis and create a funding model for one of the products of Topicus Healthcare. With the initial goal, *determining the financial flows of primary care providers*.

Determining the financial flows for primary care providers is a broad problem to be solved. Therefore, I discussed with my company supervisors about narrowing the topic. This led to one of the new products Topicus is currently working on called Spreekuur. With Spreekuur, Topicus wants to make online consultations between patient and care provider possible. With new products, it is always the question of whether the investment is worth it. Currently, Topicus is in a pilot with one of its customers. Other general practices are curious about the results of this pilot, and whether the product is also valuable for their organization. Since, currently, most general practices have some uncertainty about the financial changes that occur when they make use of the application.

To find the core problem, a spin-off of the managerial problem-solving method (MPSM) of Heerkens and van Winden (2017) is used. With this method, the core-problem is reached in four steps, which is a solvable problem with the highest urgency. The first step is to make an inventory of all existing problems related to Spreekuur. These problems are collected by interviewing employees of the division of Topicus, and by looking into documents of the company.

The next step is to indicate the relationships between the problems. The causes and effects are then used to make a problem cluster, see Figure 1. With the problem cluster a clear overview of the situation, showing relationships, is created. Additional information about the problem cluster is given below.

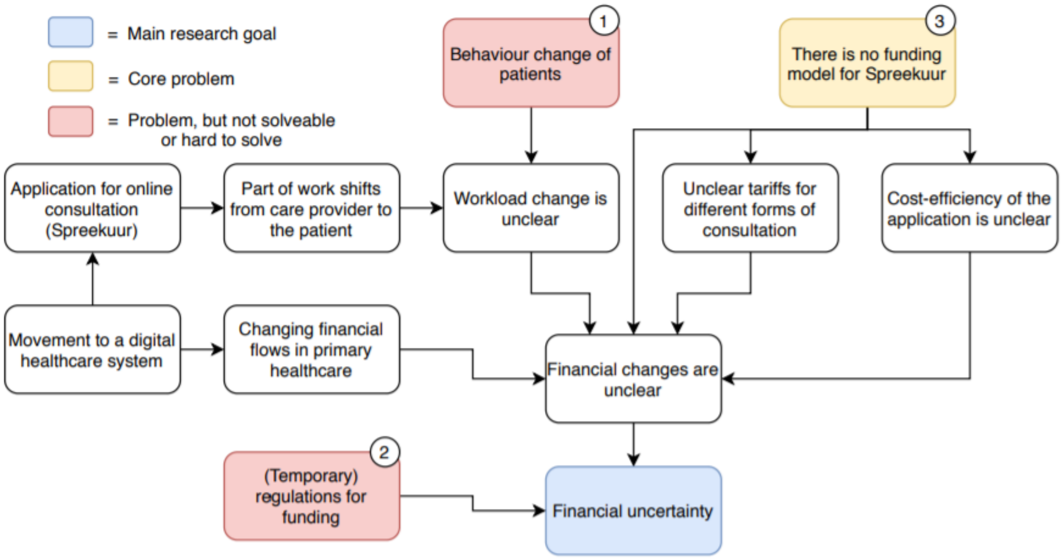

Figure 1: Problem cluster - Spreekuur

Three problems have been selected for further explanation. These problems all have a certain degree of influencing the financial uncertainty at general practices, which is the main research goal. The cause "Movement to a digital healthcare system" is not further explained, because it is one of the reasons for Topicus to develop Spreekuur.

1. Behaviour change of patients

When general practitioners make use of Spreekuur, which is a form of digital consultation, they provide a better service to their patients, because patients have more options to get in contact with their general practitioner. To make use of this service the patient must make a personal account, which takes some time as a questionnaire must be filled in. For some, this means that they do not want to make use of the application but use the telephone consult or visit consult instead. These patients stick to the 'old' forms of consultations, instead of changing their behaviour, and try Spreekuur. Resulting in a low number of patients using the application, which has a small impact on the workload of the care provider. Meaning that organizations invested in the application but cannot benefit optimally from it.

2. (Temporary) arrangements for funding

In the Netherlands, the arrangements for funding primary healthcare are set up by the NZa (the Dutch Healthcare Authority). These arrangements change frequently because more innovations regarding e-health are developed. For general practices, it is hard to determine when it is the right moment to invest in new technologies. Furthermore, due to the coronavirus, temporary arrangements regarding the digitalization are determined for care providers (Rijksoverheid, 2020). This makes it easier for general practitioners to invest, in the time-window of the arrangements, however, it makes it harder when the time-window exceeds, resulting in financial uncertainty.

3. There is no funding model for Spreekuur

There is no funding model for Spreekuur, which causes problems about the financial changes for the general practices. For Topicus this means that when they recommend a customer to use the application, it cannot be underpinned by the financial benefits that go along with it, as these are still too vague. This keeps customers pending to invest in the application. Furthermore, in the beginning, the application is only used outside office hours, but the intentions are to use the application during office hours as well. However, consultations have different tariffs depending on the time and day. The financial changes that occur by Spreekuur are still unclear due to the absence of the funding model.

1.1.1 Core problem

The third step of Heerkens and van Winden (2017) is to choose the core problem. This core problem is the problem with the highest urgency out of the three problems identified above. Furthermore, it must be solvable within 10 weeks.

The first problem, behaviour change of patients, is hard to solve. People can be very strict to their old habits, which makes them less likely to use other methods when the old methods are still working. To convince patients of using the application, communication between patient, care provider and Topicus is necessary. Furthermore, the patient must take an active role in this process. For the thesis, behaviour change of patients takes too much time. Therefore, it is not suitable as a core-problem.

The (temporary) arrangements for funding, which is the second problem, are created by the NZa. This means that Topicus does not influence the developments of these arrangements, making it a non-solvable problem.

The third problem, there is no funding model for Spreekuur, seems solvable within 10 weeks and has the highest urgency out of the three problems. Thus, the absence of a funding model for Spreekuur is the core problem to be solved in this thesis.

The core problem is reached, which implies that the last step of Heerkens and van Winden (2017), making the problem measurable, is applicable. At this moment (reality), there is no funding model, while there should be one (norm). Based on this core problem, the research question is:

Which requirements should the funding model for Spreekuur have such that it provides relevant information for primary care providers, taking different scenarios into account?

1.2 Problem-solving approach

To answer the research question, and solve the core-problem, a problem-solving approach is constructed, see Figure 2. This approach is based on the MPSM (Heerkens & van Winden, 2017) but has some modifications to suit the project better. The first two steps are part of the project plan, whereas the other steps are part of the thesis. Furthermore, the scope of the research is also determined in this section. Some parts take too much time and are, therefore, left out of the thesis.

Step 1. Problem identification

The first step of the MPSM (Heerkens & van Winden, 2017) is identifying the problem, see Chapter 2. The problem identification process is divided into four different steps: drafting inventory of all existing problems, making a problem cluster, choosing the core-problem, and making the problem measurable. When the problem is reached out of the problem-cluster, it gives a better understanding of the end goal. With the information, the approach to reach this end goal can be formulated, which is part of the next step.

Step 2. Formulating the problem-solving approach / research design

In this step, the problem-solving approach and research design are formulated. This is the last step of the project plan, related to the problem. In the problem-solving approach, all the steps that must be taken to reach the end goal are explained and motivated. The research design includes the knowledge questions, necessary to answer the research question. Key concepts of the design are research method, operationalization of key variables, data collection method and data analysis method.

Step 3. Gathering data about the current situation

During this step, all data regarding the current situation in primary healthcare are gathered. This is information about the financial situation of general practitioner care and the developments of digital care within primary healthcare. This step overlaps with the next step because it could take some time to make an appointment with participants for an interview. Furthermore, during the interviews, information for the next step is gathered as well.

Step 4. Gathering data about the financial flows of Spreekuur

Information about the different financial flows of Spreekuur is gathered. Determining which factors determine the cost-efficiency of Spreekuur and are, therefore, important for the funding model. This step overlaps with the previous step because some information is gathered during the interviews.

Step 5. Creating a framework of analysing methods

In this step, a (systematic) literature review is used to collect information about different analysing methods. With the information, a framework of the methods can be created. This step is an addition to the MPSM, as more information about the cost-efficiency is collected.

Step 6. Testing the analysing methods based on different scenarios

At this point, all data should have been collected. Furthermore, there is a basic idea of how the funding model should look like. During this step, the data are analysed in SPSS or in Excel. Before that is possible, first, the analysing methods are chosen for the corresponding data sets. Scenarios are created for the data sets. These must fulfil the assumptions of the analysing method, otherwise the results are not valid. The scenarios are evaluated with my supervisors, and adjustments are made when necessary. After that, they are analysed.

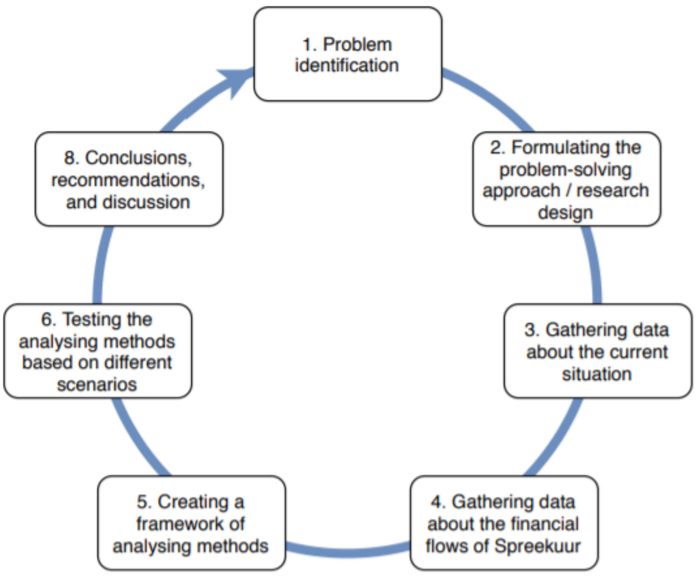

Figure 2: Problem-solving approach

Step 7. Conclusion, recommendations, and discussion

The last step is to conclude whether Spreekuur is cost-efficient based on the results of the analyses. After that, recommendations about the future of Spreekuur are given to Topicus. In the discussion, the shortcomings and assumptions of this research are discussed.

1.3 Research design

To obtain an answer to the research question and to solve the core problem, several knowledge questions must be answered. These are based on the missing data that are required to answer the research question. The information is limited to only data that are relevant for the cost-efficiency of Spreekuur. In this research design, the knowledge question with the corresponding research method is defined first. Operationalize the variable if possible and explaining the step of the problem-solving approach the question relates to. Next, the motivation, data collection method and data analysing method are described. The sections end with an outline of the reliability, validity and limitations issues of the research design that might occur.

1. The current financial situation in primary healthcare

> *What are the current financial flows for funding primary healthcare related to Spreekuur?*

Gathering the data about the current financial flows for funding primary healthcare is part of Step 3 of my problem-solving approach. For my research, it is important to get a clear overview of the current financial situation of general practices. This is information about the current funding system, tariffs of the different forms of consultation, and all other costs and income that are relevant for the thesis, which means that the data influences the cost-efficiency of Spreekuur. The main research method to gather this information is quantitative research but it has some qualitative aspects as well. Quantitative interviews with the research population, in combination with quantitative observations, are held to retrieve the data. Issues, regarding unclarity of the information, are clarified by qualitative interviews. The research population consists mainly of employees of Topicus and a general practitioner. Further information is gathered from the literature.

2. Developments and innovations regarding e-Health

> *What are the arrangements regarding subsidies and bonuses for developments and innovations in primary healthcare regarding digital- and remote care?*

The information to answer this knowledge question is gathered in step three of my problem-solving approach. Information about the regulations for future funding of digital- and remote care in primary care is one of the topics. Other information is collected to create an overview of all the bonuses, which a care provider with Spreekuur may claim. Furthermore, the criteria for possible subsidies for developments and innovations should be listed. Most information is collected through descriptive research and are found in the literature. For some additional information, qualitative interviews are used to interview employees of Topicus, and if possible, an employee of the NZa as well.

3. Changes that occur by the implementation of Spreekuur

> *Which changes occur at a general practice during and after the implementation of Spreekuur?*

Qualitative research is used to gather most of the data to answer the knowledge question. This is part of Step 3 of my problem-solving approach. First, information about the implementation of Spreekuur are gathered. This is done by a qualitative interview with a general practitioner that already has working experience with Spreekuur. Further information is gathered by reading Spreekuur documents of Topicus and the general practice. Also, it is checked how Spreekuur fits in the current developments and innovations regarding e-Health and how it fits in the current situation of primary healthcare

(Knowledge Questions 1 and 2). With the information, possible scenarios that could appear with the implementation of Spreekuur at a general practice are created. These scenarios are created with the help of employees of Topicus.

4. Literature study for the funding model

Which financial analysing methods and funding theories can be found in literature to determine cost-efficiency and how can they be applied to practice?

To make a funding model for Spreekuur, different theories and methods to transform the data into a model should be listed. Also, any restrictions, criteria and other relevant information about the model and cost-efficiency are gathered. Descriptive research is used by constructing a systematic literature review. As it should be close to the research, the main points of the systematic literature review were cost-efficiency and primary healthcare. Eventually, five sources were found.

Reliability, validity, and limitation issues

In this research some reliability, validity and limitation issues occur. According to Cooper and Schnidler (2014) "Validity is the extent to which a test measures what we actually wish to measure" and "Reliability has to do with the accuracy and precision of a measurement procedure". They are closely related to each other and both could be influenced by limitation issues of the research design. Some of the issues are already discussed. This section highlights them and explains how they are solved.

Scenarios for the funding model

The created scenarios, that might occur by the implementation of Spreekuur, should represent reality. These are based on information from the general practice that already has working experience with Spreekuur, as they are currently in a pilot. However, the current situation is different due to the coronavirus. Therefore, scenarios are made with the help of employees of Topicus to make sure they represent reality as good as possible.

Interpretation of the data

The collected data about the current funding at a general practice and the data about the pilot of Spreekuur are always clarified during the interview. This prevents me from interpreting the data wrong.

1.4 Theoretical framework

This chapter outlines the theoretical perspective on the main construct. After that, a theoretical framework on the fourth knowledge question of the research design is developed.

Topicus has developed Spreekuur but there is still uncertainty about the cost-efficiency of this product. In the research question, information about the cost-efficiency of Spreekuur is the relevant information that is provided to the primary care providers. Cost-efficiency is the amount that is achieved with a certain amount of money, or in other words spending efficiency (Nikolov, 2013). In this research, Spreekuur is cost-efficient, as the costs of the primary care organization are lower after the implementation of Spreekuur. These costs are only related to the activities that are influenced by Spreekuur, e.g. consultations.

Another main construct is the different scenarios. These are constructed, with help of my supervisors, by the data that is acquired by the interview about the pilot.

Next, the theoretical framework can be constructed based on the following research question:

Which financial analysing methods and funding theories can be found in literature to determine cost-efficiency and how can they be applied to practice?

From this research question can be concluded that the gathered knowledge must be applied to practice, which in this case is determining the cost-efficiency of Spreekuur with a funding model. Several variables have been determined to do this, see Table 1 below.

Table 1: Variables

Variable	Relation	Measurement
Region of general practice (IV-DV)	The amount of funding that a general practice gets depends on the region.	Literature
Patients (IV-DV)	The number of patients that use the application is input data of the model that must be analysed.	Interviews
Size of general practice (IV-DV)	The number of employees that do the consultations with Spreekuur input data of the model that has to be analysed.	Interviews
Time savings (MV-(IV-DV))	The amount of time saved is affected by the number of patients that make use of Spreekuur and the number of employees.	Interviews
Accessibility (MV-(IV-DV))	The accessibility of the general practice is affected by the number of patients that make use of Spreekuur and the number of employees.	interviews

1.5 Deliverables

This chapter outlines the main deliverables of the bachelor thesis. The following is delivered to Topicus:

- An overview of the current situation in primary healthcare.
    - An overview of the current funding system for general practices.
    - A criteria list of the arrangements regarding subsidies and bonuses for developments and innovations in primary healthcare regarding digital- and remote care.
- An overview of the changes that occur during and after the implementation of Spreekuur at a primary care providers organization.
- A funding model about the cost efficiency of Spreekuur in different scenarios.

2. Current situation primary healthcare

This chapter provides a general overview of the current situation in primary healthcare, which is the sector Topicus has created Spreekuur for. Giving information about what happens at most general practices, which forms of care processes there are and how patients go through these care process. With information about the current situation, the reader gets a better understanding of how Spreekuur may fit into primary healthcare. Changes at a general practice that occur with and after implementation are explained in Chapter 4.

There are several fields of Healthcare for which Topicus creates their systems for. One of those fields is the primary healthcare. The primary healthcare in the Netherlands consists of several sectors. This thesis focusses only on general practices and general practice centres because these two are related to Spreekuur. The main difference between those two are the workings hours. The general practice is generally helping patients from Monday till Friday between 08:00 hour and 18:00 hour. While the general practice centre is more for emergency cases with opening times from Monday till Friday between 18:00 hour and 08:00 hour, and Saturday and Sunday between 08:00 hour and 18:00 hour (NZa, 2020). These are general time indications and could vary per general practice.

2.1 General practice

The General Practitioner (GP) is the first person of contact in the healthcare system of the Netherlands. A patient can go to a general practice during office hours for all kind of health complaints. Interviewing general practitioners gave me insight into the care process of a patient. This is a general process and goes as follows.

When a patient has a health complaint, he calls the general practice for an appointment. Regularly there is some waiting time before the patients can speak to the doctor's assistant (triagist). During busy moments of the week, e.g. Monday mornings and break moments in the afternoon, this waiting time can be up to ten minutes. After the waiting time, the triagist carries out a triage, determining the urgency of the complaint of the patient, which is one of the six urgency categories from Table 2. It depends on the doctor's assistant what to do with the patient after the triage. Either help the patient immediately, or make a follow-up appointment with the GP for him. There are multiple ways to do the follow-up appointment, which are telephone consultation, physical consultation and visit consultation. The GP of the practice is end responsible for the decision that the doctor's assistant makes, depending on the agreements between them, the GP checks this decision. Information from the interviews shows that most of the time, the patient has a physical consultation as the follow-up appointment.

Table 2: Urgency categories (InEen, 2018)

Urgency Level	Threat	Treatment time window
U0	Failure of vital functions	Reanimation
U1	Critical condition	Immediately
U2	Threat to vital function or organ damage	As soon as possible
U3	Real risk of damage	Within several hours
U4	Negligible risk of damage	Within 24 hours
U5	No chance of damage	Next day

Telephone consultation

Telephone consultation is one way to do the follow-up appointment. Then the patient is called back by the GP at the given timeslot. Some general practices have a daily telephone consultation hour (Independer, 2020). When a patient calls the general practice during a telephone consultation hour, he immediately gets an answer from a GP, which is excluding waiting time. This saves the patient time because he does not have to come to the practice and does not have to tell his story to a doctor's assistant first. A telephone consultation is not suitable for all kinds of medical questions. Rather simple questions or clarification questions are suitable for a telephone consultation. For more urgent and complex question a physical consultation or visit consultation is better because of the visual contact.

Physical consultation

Physical consultation is another way to do the follow-up appointment. The patient has given a timeslot for the appointment from the doctor's assistant. At this timeslot, the patient must come to the general practice. Here he must wait in the waiting room till the GP has time for him. This form of consultation is suitable for all kinds of medical issues because the GP can see the patient and his complaint. A downside of physical consultation is the amount of time it takes for both the patient and the GP.

Visit consultation

A visit consultation is also a way to do the follow-up appointment. This is only for patients that cannot come to the general practice because of medical complaints or a handicap. In this situation, the GP visits the patient at their home.

Other ways of consultation

Furthermore, most general practices have an eHealth module nowadays. This can be an email or another form of digital consultation. This also means that general practices use a regular (secured) email address to answer the questions that patients ask via the email.

2.2 General practice centre

The general practice centre works almost the same as a general practice but there are still some differences. The biggest difference is already discussed namely the openings hours. Furthermore, a general practice centre is mainly for emergency cases and is available for patients from multiple general practices of the region. For the patient, this means that the GP that helps him with his health complaint normally is not the familiar GP from his general practice.

Making an appointment as a patient is similar to making an appointment with the general practice, but the patient calls the general practice centre instead. Because a general practice centre covers more patients than a single general practice, it is more likely that the patient must deal with some waiting time before he gets an answer. When he does, the doctor's assistant carries out the triage and determines the urgency of the health complaint. The urgency determination is an important step because general practice centres are mainly for urgency cases. In the case of a low urgency complaint, the treatment window is larger (Table 2), which means that the patient can go to the general practice the next day. When it concerns a more urgent case a follow-up appointment, which is one of the options that is also possible at a general practice, is made with the patient, or the doctor's assistant decides to help the patients immediately. This decision is always checked by the GP on duty at the general practice centre.

2.3 Organisation

General practices and general practice centres are part of the primary healthcare in the Netherlands, but there are more care providers in this sector. In a region, these care providers can form a care group, called a care group. Together with the health insurance company they mostly work with, they make agreements to coordinate the care provided to the patients in the region, which should increase the quality of health care (NMa & NZa, 2010). The care group is obligated to provide the quality of care that is agreed on. In return for that, they get paid by the health insurance company.

In addition to that, care groups can take responsibility for the information provision of patients. Also, they can retrain care providers, collect data about the provided care and inform patient about the different care processes. Which is all done to maintain the quality of care that is provided to the patients (NMa & NZa, 2010).

2.4 Registration of patients

In the Netherlands, every general practice makes use of a GP information system (HIS)(LHV, 2020). This is an ICT system where a general practice stores information about their patients. This includes a patient record, patient appointments, and prescribed medication. Furthermore, declarations are also made with the HIS. General practices can choose their HIS from multiple options (De Boer & Bosman, 2018). For the quality of care that the general practice provides to their patients, it is important to choose a good HIS. The efficiency of the general practice is depended on it. Furthermore, a HIS contributes to the service, accessibility, and financial settlements of the general practice. Therefore, a HIS must meet certain criteria (VZVZ, 2019).

Topicus creates software that makes use of the information out of the HIS of the general practice. VIPLive is one of them. This software helps general practitioners and healthcare groups with declarations, administration, and healthcare processes.

For general practice centres, they have another system, which is called Topicus HAP. Topicus HAP is an electronic patients’ file (EPD), which helps the general practice centre with the care process and registration of contact information of patients. This includes the consultation, registration of care process and which mediation they have prescribed to the patient. This is all accomplished in one application and therefore it gives a clear overview which makes it efficient for the user. The application is comparable to a HIS system, but then, for general practice centres. The consultations are also registered in the HIS system of the patients' general practitioner so that he is aware of the patient's visit.

3. Financial situation

This chapter outlines the financial situation of primary healthcare. The collected information is helpful to answer the first knowledge question: *"What are the current financial flows for funding primary healthcare related to Spreekuur?".* This includes funding of primary healthcare, which is separated into three different segments and a performance segment. This covers the incomes of general practices and general practice centres, and performance bonuses and funding for innovations regarding digital healthcare. In addition to that, this chapter also covers the main costs that general practices and general practices centres have.

3.1 Funding primary healthcare

In the Netherlands, practitioner care is funded through the healthcare law. Every year the ministry of public health determines the budget for the primary care. This budget is separated into three main segments and a performance segment:

- Segment 1. Basic provision of practitioner care, which uses most of the budget
- Segment 2. Multidisciplinary healthcare
- Segment 3. Innovation within practitioner care.

The performance segment includes the funding for costs made outside the other three segments, e.g. practitioner healthcare in the general practice centre (NZa, 2020).

3.1.1 Segment 1: Basic provision of practitioner care

This segment focusses on the basic forms of healthcare that the general practitioners provide to their patients. For patients with health-related questions or health complaints, the GP is their first person of contact. The GP can provide diagnoses, treatments and guide them further. Segment 1 links tariffs to those performances, which makes it the main source of income for general practices. Most of these tariffs are fixed, maximum tariffs but there are some variable tariffs as well (NZa, 2020).

Registration fee, consultations, mental health support (POH-GGZ), other care operations, participation in the OPEN program, the healthcare provided in primary care addresses and intensive care, are all part of Segment 1 (NZa, 2020). Only the registration fee and consultations are possibly influenced by the implementation of Spreekuur and are, therefore, further explained in this thesis.

Registration fee

The first source of income for a healthcare provider is the registration fee. To obtain this amount, the practitioner must be available for the patient, 24 hours per day and seven days per week. The registration fee should fund the costs for availability, which includes the time outside the general practice hours, and should also cover a part of the costs made by providing care (NZa, 2019c). Furthermore, the interview with a general practitioner financial statement adviser shows that the registration fee should cover the fixed costs of general practitioners, such as rent and wages.

The tariff of the registration fee for a patient depends on two variables (NZa, 2019c). The first variable is the age of the patient. Older people are generally more eligible for the services of a general practitioner, therefore a general practice receives more registration fee for them. The variable is separated into four different categories, see Table 3. The other variable is the residence of the patient. For patients that live in a disadvantaged area, the registration fee is higher. Every year the NZa set a fixed, maximum number to the variables, which results in Table 3 for the year 2020.

Table 3: Maximum tariff for the registration fee (NZa, 2019c)

Age of patient	**Maximum tariff for patients that do not live in a disadvantaged area**	**Maximum tariff for patients that do live in a disadvantaged area**
Till 65 years	€16.54	€21.73
Between 65 years and 75 years	€19.41	€24.61
Between 75 years and 85 years	€29.41	€34.35
Older than 85 years	€45.71	€50.91

The maximum tariffs are not the final tariffs that the general practitioner receives per patient because they discuss this with the health insurance company. Together they determine the registration fee, which is paid every quarter to the care provider by the health insurance company. This is only the case if the patient registered himself by the general practitioner without being forced to do so.

Consultations

A consultation is a contact between the patient and the care provider (NZa, 2019c). For this contact, the care provider gets a maximum tariff funding a part of the made costs. The maximum tariff is time-dependent, separated into three time categories, see Table 4. For this thesis, only regular consultations are considered, because these are only influenced by the usage of Spreekuur. The passer-by, military, and conscientious objectors' consultations are unchanged and, therefore, not relevant to the model.

Table 4: Maximum tariff for regular consultations (NZa, 2019c)

Regular consultation duration	**Maximum tariff**
Less than 5 minutes	€5.07
Between 5 and 20 minutes	€10.15
Longer than 20 minutes	€20.29

In a regular consultation, the patient is always registered by the concerning general practitioner. A consultation can have different forms, see Chapter 2. These forms are physical consultation, telephone consultation, digital consultation and visit consultation. For a visit consultation (Appendix A) the maximum tariff is higher than the numbers in Table 4 because there are more costs associated with it, e.g. transport costs. Since the start of 2019, the other three consultation forms have been funded following the regular consultation tariffs, which makes it easier for care providers to charge their care services at the health insurance company (NZa, 2019d). Telephone consultation and digital consultation are only funded when the provided healthcare and quality are good, which means that the healthcare provision content and duration are comparable to that of a physical consultation (NZa, 2019d).

3.1.2 Segment 2: Multidisciplinary healthcare

The financial flows from Segment 2 are for integrated care that general practitioners provide to patients with chronic health issues, which are patients with diabetes, cardiovascular diseases, or chronic lung diseases. During these also other care providers, then general practitioners are integrated into the process. A supporting structure is helpful to optimize the quality of multidisciplinary healthcare. Therefore, organisation and infrastructure (O&I) is the first category of this segment. The other two categories are Segment 2A (S2A) and Segment 2B (S2B)(NZa, 2020).

Organisation and infrastructure (O&I)

Since 2018 the NZa has introduced several subcategories for the category O&I in Segment 2, which allows healthcare providers to get additional reimbursements for the made agreements with health insurance companies. The additional reimbursements have the goal to stimulate cooperation between different care providers, which should benefit the patient because the costs should decrease and the quality of healthcare should increase (NZa, 2020). In total there are four different subcategories for the O&I. Each funding tariff for the subcategory depends on the agreements that the care providers make with the health insurance company. This funding is for every insured person registered by the general practitioner who is part of the multidisciplinary partnership (NZa, 2019c). The funding is paid every quarter.

The first subcategory is O&I district management. This is a multidisciplinary partnership at a district level, which has a population between the 10,000 and 20,000 patients. Together they make agreements about investments that should optimize the cooperation between the care providers in primary care, which should lead to a better quality of healthcare or a stable level of healthcare costs (NZa, 2019c). To achieve this, they create a plan based on the healthcare preferences of their target group. The second subcategory is O&I integrated care. This concerns the funding for organising and maintaining the quality cycles of the quality and costs of integrated care. The third subcategory is O&I region management. This is also a multidisciplinary partnership like the O&I district management. Except, in this case, it is at a region level, which is for a population between the 100,000 and 200,000 patients. The last subcategory is remaining integrated primary care. This subcategory is for care providers and health insurance companies that want to continue with their current agreements, but these agreements do not fit into the other subcategories (NZa, 2019c).

Segment 2A, Multidisciplinary healthcare – Contracted and Not contracted (S2A)

The category Segment 2A is separated into two different subcategories, contracted multidisciplinary healthcare, and not contracted disciplinary healthcare. The chronic health issues in this segment are patients with diabetes, cardiovascular diseases, or chronic lung diseases (NZa, 2020). The care group receives funding for the healthcare services provided to the patient in the integration. In the process, concerned care providers receive payments from the care group (Zó werkt de zorg, 2020). The tariff for contracted multidisciplinary healthcare depends on the agreements that the care group makes with the health insurance company. For not contracted multidisciplinary healthcare a maximum tariff is set by the NZa. The care group must meet certain criteria to claim the funding. More details are found in Beleidsregel huisartsenzorg en multidisciplinaire zorg 2020 (NZa, 2020).

Segment 2B (S2B)

The category Segment 2B has no subcategories at this moment (NZa, 2020). It is meant for new forms of integrated care that do not fit into Segment 2A. For these new forms of integrated care, national agreements on the approach and underlying healthcare standards exist.

3.1.3 Segment 3: Innovations within practitioner care

Healthcare innovations and services that increase the accessibility or quality of healthcare are part of Segment 3. Between 5% and 10% of the total budget within practitioner healthcare, is used for Segment 3, making it the lowest financial flow (Zó werkt de zorg, 2020). This segment has two main categories, separated into subcategories. Health insurance companies and care providers make agreements about the results of provided healthcare and innovations within primary healthcare.

Result reward

The first category in Segment 3 is result reward. This is a reward for the results of the healthcare process provided by general practitioners. The results can only be rewarded when it is part of one of the three following categories, registration fee (Segment 1), diabetes or cardiovascular diseases contracted multidisciplinary healthcare (Segment 2), cardiovascular diseases or chronic lung diseases contracted multidisciplinary healthcare (Segment 2)(NZa, 2020). This means that the reward is added to one of those categories, increasing the payments the practitioner receives from the health insurance company.

Several results can get rewarded, only the two relevant results for this thesis are explained further. These results are relevant because the implementation of Spreekuur can positively influence it. The general practice can make agreements with the health insurance company about the corresponding rewards. More information about the other results can be found in Beleidsregel huisartsenzorg en multidisciplinaire zorg 2020 (NZa, 2020).

The first result reward is for service and accessibility. General practitioners make agreements with the health insurance company to add an extra payment to the registration fee when they have improved their service or accessibility. Examples of improvements are the possibility for patients to make an appointment online or increasing the opening hours of their general practice (NZa, 2020). The second result reward is for stimulation of practitioner care in shrinking regions, which are regions that encounter a decrease in population. In the Netherlands, there are a total of nine shrinking regions (Rijksoverheid, 2018).

Primary healthcare innovations

Innovation within primary healthcare is the second category in Segment 3. This category is separated into three subcategories: eHealth, watch consultation and remaining. For this thesis, only the eHealth subcategory is relevant because the Spreekuur application only might claim those rewards. General practices can make agreements with a health insurance company about funding or rewarding the use of eHealth. This is only the case when it is a form of digital treatment or it is a digital product for the self-management of patients. With the implementation of Spreekuur, patients do their triage online, instead of a doctor’s assistant that carries out the triage. For a triage, the general practice cannot fund anything, but it could save time that the doctor’s assistant can use for something else. Therefore, general practices might make agreements with health insurance companies about funding or rewarding it.

3.1.4 Performance segment

All performances that do not fit into the three main segments are part of the performance segment. This segment used 386 million euro (12%) of the total general practitioner care budget in 2017, which was two times as much as Segment 3 (Zó werkt de zorg, 2020). This thesis only explains the funding for the medical operations at general practice centres hours. The NZa separates the maximum tariff for this into two categories. The first category is for general practitioners that perform medical operations and participate in a general practitioner’s structure (hds), and the other category is for general practitioners that do not participate in a general practitioner’s structure (hds).

When a general practitioner participates in a hds, they charge the bill of their services by the concerned hds. The NZa has a maximum tariff for these services, which is per working hour, see Table 5. This is only the maximum tariff, the amount that the practitioner can charge also depends on the agreements the hds makes with the health insurance company.

Table 5: Maximum tariff for working hour (hds) (NZa, 2019c)

Performance	Maximum tariff
Working hour (hds)	€78.00
Raise working hour (hds)	€15.00

For general practitioners that do not participate in a hds, the maximum tariffs are set for the consultations. Therefore, they look like the maximum tariffs for regular consultations, except that they are higher, see Table 6.

Table 6: Maximum tariff for consultations (without hds) (NZa, 2019c)

Consultation duration	Maximum tariff
Less than 5 minutes	€25.44
Between 5 and 20 minutes	€50.87
Longer than 20 minutes	€101.74

3.2 Costs of a general practice

The tariffs that the NZa sets for the services of general practitioners in the three segments are determined to cover their costs. Interviewing a general practitioner financial statement adviser shows that employee costs are the biggest expense of general practice. The report of Stichting KOH (Derckx et al., 2015) provides a clear overview of the costs and income of a general practice, see Table 7. They have reported that approximately 72,6% of the total costs are employee costs. According to the same report and the interview with a general practitioner financial statement adviser, the housing location costs of the general practice are a big expense as well. For general practices located in the western part of the Netherlands, these costs are higher.

Table 7: Costs of a general practice (Derckx et al., 2015)

Activity	Costs (%)
Employee costs	72.6 %
Housing location costs	10.7 %
IT costs	3.6 %
Organisational costs*	13.1 %
Total	**100%**

* Organisational costs are the costs for insurance, depreciations, general costs and more.

4. Digitalisation within primary healthcare

This chapter outlines the developments and innovations regarding digitalisation within primary healthcare, describing how a more digital work environment can lower the workload of care providers. This is necessary because they get more responsibility and more healthcare-related questions from the population. Furthermore, the chapter further explains how Spreekuur is part of the digital developments, and which changes must occur at a general practice to make Spreekuur cost-efficient.

Workload of general practitioners

The role of general practitioners in the healthcare system in the Netherlands has already been mentioned in Chapter 2. General practitioners are the first persons in line which help patients with a health-related question. Even though they are the first point of contact, the patient tends to skip this step and immediately goes to the first aid at the hospital. In most of these cases, a GP can help the patient as well. Therefore, the national government of the Netherlands wants to stimulate general practitioners to help as many patients as possible (Rijksoverheid, 2020). The cabinet of the Netherlands wants more collaboration between general practitioners and the first aid at the hospital. A general practitioner can avoid a patient's visit at the hospital, saving the patient and society money (Rijksoverheid, 2020). A visit to the hospital is generally more expensive than visiting a general practice. Therefore, general practitioners are also called the gatekeepers of the Dutch healthcare system. They make sure that patients go to the right specialist when this is necessary, which increases their responsibility.

A bigger responsibility also increases the workload of general practitioner care, which is already high (Kleijne, 2019). This topic was also discussed in my interviews with general practitioners. The population is ageing, this includes the patients but also the GP themselves. Older patients claim more care than the younger generations, therefore the workload increases. Furthermore, there are too few doctor's assistants. At the end of 2017, a general practice centre had on average a shortage of doctor's assistants of 1,57 FTE (InEen, 2018).

4.1 Innovations

More digitalisation in primary care can help to lower this workload. Necessary is to use these tools as efficiently as possible. Currently, there are many innovations regarding the digitalisation of healthcare. The NZa stimulates these developments with several performance bonuses and subsidies, see Chapter 3. For healthcare innovations that do not fit into the performance bonuses of Segment 3 because they are new experiments, the NZa has created a policy rule (NZa, 2019a). With the policy rule, it is possible to experiment with innovations at a small scale for a maximum period of three years. However, certain criteria are attached to this. The first criterion is the main goal of the innovations, which must aim for a better value for money of primary healthcare. This can be achieved by a new way of healthcare providing, or by a more efficient care organisation, or by a quality increase of the delivered healthcare. The second criterion is an agreement with between one or more care providers with one or more health insurance companies. These are, for example, agreements about the tariffs and about the expected results. The third criterion is about other similar experiments or performance bonusses. This means that at the time of submitting the experiment of the innovation by the NZa the innovation is new in primary healthcare. These are the three main criteria of the policy rule of the NZa. Fulfilling these criteria means that the concerned care providers and health insurance companies can full in the format for innovations regarding new performance bonusses (NZa, 2019b), and send it to the NZa. The NZa then decides whether the innovation receives a payment title, which means that the innovation can be tested in practice.

4.2 Spreekuur application

Digitalisation becomes more and more a part of primary healthcare. Also, people become more digitally aware. Nevertheless, it is hard to fit new technologies in, which means that old habits must change. The current situation in primary healthcare is explained in Chapter 2, which mentions that there are several ways to do a consultation between a patient and a care provider. One of those ways is the eHealth module that some general practitioners provide to their patients. Currently, this is mostly in the form of email messaging. The use of email messaging is not used much, because general practitioners were uncertain about the tariffs for them. Therefore, the NZa changes the maximum tariffs for telephone consultations, physical consultations and digital (email) consultations. Now they all have the same maximum tariff, see Chapter 3.

The equalisation in tariffs is already the first step in integrating Spreekuur into the system of general practices. In addition to that, they also changed another old policy. Therefore, it is possible to send a patient to a specialist via a telephone consultation or digital consultation, instead of being limited to do this only via a face-to-face consultation (Jacobs, 2019).

All these developments give Spreekuur the opportunity to come up in primary healthcare. People are more digital than ever, and in different times digital applications are an option because people can use them everywhere. Currently, during the corona virus, digital innovations are even more interesting because patients can stay at home, which makes it a safe form of consultation. However, there should be more benefits for general practitioners that implement it, otherwise, they could use telephone consultations or email consultations instead because those forms are cheaper. To calculate whether Spreekuur is cost-efficient for general practitioners, the application should increase the income, decrease the costs, or a combination of both at a general practice or general practice centre.

4.2.1 Funding for Spreekuur

The income can be increased in several ways. Chapter 3 already covers the current funding in primary healthcare. Most of the income of general practitioners come from the registration fee (Segment 1), which is dependent on the age and living area of the patient, see Table 3. Furthermore, the registration fee can be increased by adding some extra modules from Segment 3. For several results, the general practice gets rewarded, which means that they get more paid for the registration fee per patients. When a general practice implements Spreekuur, they make could claim two of those result rewards, which are the result reward for service and accessibility, and the result reward for the stimulation of practitioner care in shrinking regions. They always must make agreements with the health insurance company about these rewarding's because the results vary per general practice. Another main form of income is the income from consultations. This income is only dependent on the duration, separating the maximum tariff into three different categories, see Table 4. This means that a general practice wants to do as many consultations per day as possible but wants to contain the quality of the provided care as well. An important legal framework is the Quality, Complaints and Disputes Care Act (Wkkgz) in the Netherlands. It defines standards for providing care of a good quality. Furthermore, just like the tariff for the registration free, is the tariff for regular consultations an agreement between the care provider and health insurance company.

Therefore, it is most important to decrease the costs of general practices. In Chapter 3 the main costs of general practices are given. Employee costs are, with over 70% of the total costs, the biggest form of costs. Decreasing the number of employees is only possible when general practices work as efficiently as possible. Which becomes even more crucial as the demand for general practitioner care increases. Therefore, general practices could also prevent an increase in employee numbers, by working more efficiently, which would lead to helping more patients with the same capacity.

Determining whether Spreekuur is cost-efficient for general practices has, hence, a lot to do with the efficiency of the application. To calculate this efficiency the right analysing method is searched for in literature, see Chapter 5. In addition to that, it is also possible to decrease the employee costs, when doctor's assistants can do consultations with Spreekuur. Currently, most consultations are between the general practitioner and the patient, which is more expensive than consultations between the doctor's assistant and the patient. When doctor's assistants become familiar with the application, they are also able to do Spreekuur consultations. This means that the general practice saves money, by deploying less expensive employees. Chapter 2 explains that doctor's assistants already take over some other forms of consultations at the general practice or general practice centre. Another aspect that decreases the costs of general practices with the implementation of Spreekuur, is the costs for the housing location. With Spreekuur, general practitioners can work from home, which means that the general practice can rent fewer rooms. The number of costs that the general practices safes with this depends on the location.

5. Analysing methods

This chapter covers the different efficiency analysing methods found in the literature. Providing a framework of the most used analysing methods in a medical context. The methods that compare the difference in means of two groups are explained in more detail.

The efficiency of organisations and systems in primary healthcare are analysed in several ways. Depending on the data set, the best analysing method is chosen. The number of innovations within primary healthcare increases every year. For the decision making of general practitioners, it is important to choose the right analysing method because the means are not unlimited. Medical knowledge is increasingly based on empirical studies and the results of these are usually presented and analysed with statistical methods (Du Prel et al., 2010). Analysing the efficiency of innovations or treatments is an example of more specific efficiency analysis, but it is also possible to analyse the efficiency of different general practices, with multiple inputs variables and outputs variables.

5.1 Data Envelopment Analysis

For measuring a more general form of efficiency in primary healthcare, the data envelopment analysis (DEA) has been used increasingly (Pelone et al., 2015). “DEA uses a mathematical optimization technique called linear programming to identify a best-practice frontier”, According to Taylor (2010). It is a nonparametric technique which is only based on multiple observed input and output data (Jati, 1999). It is an attractive tool to measure efficiency because these inputs are transformed into health outputs during the process. Furthermore, no strong assumptions are necessary to link the inputs to the outputs, and it measures efficiency in relative terms. (Pelone et al., 2015). However, there are also downsides in using the technique. In small samples, inefficiency levels may be systematically underestimated when the assumptions are too weak. Therefore, DEA is also used in combination with a Stochastic Frontier Analysis (SFA), which is a stochastic model. Nevertheless, DEA have become more common in measuring the efficiency of primary health care delivery organisations (Pelone et al., 2015).

5.2 Statistical tests

Although DEA is used increasingly, statistical tests are most often used in the medical context. Studies compare the efficiency of innovations in a study group with the efficiency of the original product or system in a control group (Du Prel et al., 2010). To see, whether the observed differences are real or random because there exists a chance of variability in the parameters. Several steps are determined when one performs a statistical test. First, the question to be answered and the null hypothesis are formulated (Du Prel et al., 2010). When a researcher wants to investigate whether additional training is better than only regular training, the test variable may then be the difference in spring distance of the test group and the control group. The null hypothesis is then: “There is no difference between the regular training and regular training in combination with additional training with respect to the spring distance”. After that, the error level of significance α must be specified, which in most cases is 5%. Next, must be decided if the test is a one-tailed test or a two-tailed test. This has to do with the direction of the test. In a two-tailed test, the direction of the expected difference is unclear, this means that the spring distance of the group with the additional training could be less or more, compared to the control group. In a one-tailed test, the results can only act in one direction (Du Prel et al., 2010). After these steps there are two criteria that determine the test statistical:

- The scale measurement of the test variable (continuous, category or binary)
- The type of study design (dependent or independent).

Scale of measurement

Three commonly used measurement scales are covered, which are continuous, category and binary. First, a continuous measurement scale is with data that can take on any numeric value (Frost, 2017). There are infinite options between two values, examples of continuous data are distance, height, and time. The measurement scale has two main benefits. Firstly, it is possible to draw conclusions with a smaller sample size, and secondly, there is a wide variety of analysis options, which gives the researcher more information about the information (Frost, 2017). The next measurement scale is a categorical variable. This data is separated into different categories, e.g. blood groups. When there are only two categories, it is also called a binary measurement scale. An example of binary observation data is pass/fail. This scale is often used by quality improvement practitioners to record defective units (Frost, 2017). When a goal is set, the test is useful to detect this goal.

Dependent or independent

Statistical analysis is performed on one, two or more samples. These samples are either dependent or independent of each other. With independent samples, men assume that one sample does not affect the other sample (Almukkahal et al., 2019), while dependent samples do affect each other. Therefore, dependent samples are related. This is the case, when the same testing group is measured twice (cross over design), or when an observation from one testing group matches with the observation of the other testing group (Almukkahal et al., 2019).

Common statistical tests

Based on the two main criteria and further steps, the statistical test is selected. The measurement scale is either continuous or categorical. The binary measurement scale belongs to the categorical scale. When it concerns a continuous endpoint, it is either a normal distribution or a non-normal distribution. Next, the dependency of the testing sample is determined, which is either dependent or independent. The last point of attention to select the statistical test is the number of samples, where a distinction is made between two or more than two samples (Du Prel et al., 2010). Table 8 provides a summary of the characteristics of the most common statistical tests. To determine the cost-efficiency of Spreekuur, the situation before and after the implementation is useful to measure, and to compare the difference between Spreekuur and another process. Therefore, the tests that analyse two groups are better in this situation. Most of the data is continuous data, like the number of consultations and the duration of consultations and processes. The tests that fulfil these criteria are the Student's t-test for independent and dependent samples, the Wilcoxon signed-rank test and the Mann-Whitney U test, and are, therefore, explained in more detail when and how to use them.

Table 8: Important statistical tests (Du Prel et al., 2010)

Statistical Test	Measurement Scale	Distribution	Dependency of samples	Sample size
McNemar test	Categorical	-	Dependent (paired)	-
Fisher's exact tests	Categorical	-	Independent (unpaired)	Small
Chi-square test	Categorical	-	Independent	Large (n>60)
Student's t-test	Continuous	Normal distributed (parametric)	Dependent and independent	Two groups
Analysis of variance (ANOVA)	Continuous	Normal distributed	Dependent and independent	More than two groups

Wilcoxon signed-rank test	Continuous	Non-normal distributed (non-parametric)	Dependent	Two groups
Mann-Whitney U test (Wilcoxon rank-sum test)	Continuous	Non-normal distributed	Independent	Two groups
Friedman test	Continuous	Non-normal distributed	Dependent	More than two groups
Kruskal-Wallis test	Continuous	Non-normal distributed	Independent	More than two groups

5.2.1 Dependent t-test (student's t-test)

The student's t-tests for a mean difference μ of two samples, which are paired samples in the case of the dependent t-test. The samples are pairs of dependent observations taken from normally distributed populations. The differences between the pairs is taken, which gives one sequence of differences, which can be assumed as independent (Meijer, 2018). Testing on the mean difference with the null hypothesis: "The mean difference is zero", versus the alternative hypothesis: "The mean difference is not zero", which is also indicated as H_0: $\mu = 0$ against H_1: $\mu \neq 0$, with the error level of significance α (Meijer, 2018).

Assumptions

Before one can use the dependent t-test to analyse the data, the data should be checked whether it is sufficient to analyse with the test. There are four different assumptions the data need to fulfil, to use the test and get a valid result (Laerd Statistics, n.d.). The four assumptions are:

1. The dependent variable is measured at a continuous scale. This means that the measured variables have a numeric value, e.g. duration (measured in minutes).
2. The independent variable consists of two categorical, related groups or matched pairs. By related groups, the subjects are presented in both groups. Both groups are measured twice, which is also called a cross over design. By matched pairs, an observation from one testing group matches with the observation of the other testing group (Almukkahal et al., 2019).
3. There are no significant outliers in the differences between the two related samples. Outliers have a negative effect on the test, have a negative affect on the statistical significance of the test.
4. The distributions of the difference in the dependent variable between the two related groups are approximately normally distributed. Even when this is a little violated, the test can still provide valid results. Therefore, the data must be approximately normal.

Calculations

When the data fulfil the assumptions of the dependent t-test, the test can be used to analyse the data. The sample size is not a requirement because there are no restrictions to the sample size, which makes it useful in multiple situations. To test on the mean difference between the two groups, one first calculates the differences of each of the observed pairs. Then, there is only one sequence left, which can be indicated as independent. With this sample, one can apply the one sample t-test on the mean difference, using the following test statistic (Meijer, 2018):

$$T = \frac{\bar{X}}{\frac{S}{\sqrt{N}}} \qquad (1)$$

With:

$$S = \sqrt{\frac{\sum(X_i - \bar{X})^2}{N-1}} \quad (2)$$

Where $\bar{X}$ is the sample mean with size N and sample variance *S*, and X_i is the difference of pair *i*, for *i* = 1 to N. (Meijer, 2018).

After calculating the T value, the critical value *c* is determined. This value depends on the degrees of freedom (*df = N - 1*) and the error level of significance *α*. In this case, the value of *α* is divided by two because it concerns a two-tailed test (Meijer, 2018). After that, one can derive the critical value from the table in Appendix B.4. The last step is to determine whether the null hypothesis can be rejected or not. One can reject this when the value of T is smaller or equal to the negative critical value ($T \leq -c$), or when the value of T is equal or bigger than the critical value ($T \geq c$) (Meijer, 2018).

It is also possible to determine the confidence interval of the mean difference. A confidence interval indicates the range of values where the unknown parameter lies with a certain level of confidence (Meijer, 2018). This level of confidence depends on the chosen error level of significance *α*. In most cases, this has a value of 5%, which indicates a $1 - \alpha = 95\%$ confidence level. For a 95% confidence level, the confidence interval is calculated by (Meijer, 2018):

$$95\%CI(\mu) = (\bar{X} - c \cdot \frac{S}{\sqrt{N}}, \bar{X} + c \cdot \frac{S}{\sqrt{N}}) \quad (3)$$

Where the values for $\bar{X}$, S^2 and N are the same as in Equation 1. Furthermore, the critical value *c* is the same as well, which is 2.015. This means that at a confidence level of 95% the unknown parameter, which is, in this case, the mean difference between the two groups, lies within the indicated interval from Equation 3.

5.2.2 Independent t-test (student's t-test)

The student's t-tests for a difference in means of two samples, which are unrelated groups in the case of the independent t-test. The samples in the test are taken from the normally distributed variables X and Y, in (two) populations (Meijer, 2018). Testing on the difference in means with the null hypothesis: "The difference in means between the two samples is zero", versus the alternative hypothesis: "The difference in means between the two samples is not zero", which is also indicated as H_0: $\mu_1 - \mu_2 = 0$ against H_1: $\mu_1 - \mu_2 \neq 0$, with the error level of significance *α (Meijer, 2018).*

Assumptions

The data should be checked whether they are sufficient, before one can use the independent t-test for the analysis. There are six different assumptions the data need to fulfil, to use the test and get a valid result (Laerd Statistics, n.d.). These assumptions are:

1. The dependent variable is measured at a continuous scale. This means that the measured variables have a numeric value, which can be an interval or a ratio e.g. duration (measured in minutes).
2. The independent variable consists of two categorical, independent groups. Two different treatments are examples of the independent variables.
3. The observations are independent, which means that all observations, even the observations from the same group, cannot affect each other.
4. There are no significant outliers in the differences between the two related samples. Outliers have a negative effect on the test, which results in a less valid result. Also, they have an affect on the statistical significance of the test.

5. The dependent variable is approximately normally distributed for both groups of the independent variable. Even when this is a little violated, the test can still provide valid results. Therefore, the data must be approximately normal.
6. There is homogeneity of variances, which means that the sample variances of both groups are considered equal.

Calculations

When the data fulfils the assumptions of the independent t-test, it can be used to analyse. The sample size is not a requirement because there are no restrictions to the sample size, which makes it useful in multiple situations. To test on the difference in means between the two groups, ones uses the following test statistic (Meijer, 2018):

$$T = \frac{\bar{X} - \bar{Y}}{\sqrt{S^2 \left(\frac{1}{n_1} + \frac{1}{n_2}\right)}} \quad (4)$$

With:

$$S^2 = \frac{n_1 - 1}{n_1 + n_2 - 2} S_x^2 + \frac{n_2 - 1}{n_1 + n_2 - 2} S_y^2 \quad (5)$$

Where $\bar{X}$ is the sample mean of the first sample with size n_1 and sample variance S_x^2, and $\bar{Y}$ is the sample mean of the second sample with size n_2 and sample variance S_y^2 (Meijer, 2018). Furthermore, $\mu_1 - \mu_2 = 0$ in Equation 4, as indicated by the null hypothesis.

After calculating the T value, the critical value *c* is determined. This value depends on the degrees of freedom (*df* = n1 + n2 - 2) and the error level of significance *α*. In this case, the value of *α* is divided by two because it concerns a two-tailed test (Meijer, 2018). After that, one can derive the critical value from the table in Appendix B.4. The last step is to determine whether the null hypothesis can be rejected or not. One can reject this when the value of T is smaller or equal to the negative critical value ($T \leq -c$), or when the value of T is equal or bigger than the critical value ($T \geq c$) (Meijer, 2018).

Like the dependent t-test, it is also possible to determine the confidence interval of the difference in mean between the two groups by the independent t-test. This confidence interval indicates the range of values where the unknown parameter lies with a certain level of confidence (Meijer, 2018). For a 95% confidence level, the confidence interval is calculated by (Meijer, 2018):

$$95\%CI(\mu_1 - \mu_2) = \left(\bar{X} - \bar{Y} - c \cdot \sqrt{S^2 \left(\frac{1}{n_1} + \frac{1}{n_2}\right)}, \bar{X} - \bar{Y} + c \cdot \sqrt{S^2 \left(\frac{1}{n_1} + \frac{1}{n_2}\right)}\right) \quad (6)$$

Where the values for $\bar{X}$, $\bar{Y}$, S^2 and the sample size (n_1 and n_2) are the same as in equation 12. Furthermore, the critical value *c* is the same as well, which is 2.015. This means that at a confidence level of 95% the unknown parameter, which is, in this case, the mean difference between the two groups, lies within the indicated interval from equation 6.

5.2.3 Wilcoxon signed-rank test

The Wilcoxon signed-rank test is a non-parametric test that uses paired study data. Therefore, the test compares the mean of two dependent samples. With the null hypothesis: “The median difference between the pairs of observation is zero”, versus the alternative hypothesis: “The median difference between the pairs of observation is not zero” (O’Loughlin, 2017).

Assumptions

Before one can use the Wilcoxon signed-rank test to analyse the data, the data should be checked whether it is sufficient to analyse it with the test. There are three different assumptions the data needs to fulfil, to use the test and get a valid result. The assumptions are like the assumptions of the Mann-Whitney U test, except for the difference in the dependency of the testing groups. The three assumptions are:

1. The dependent variable is either measured at the ordinal level or at the continuous level. For ordinal variables this means that they are measured in scales or categories, and for continuous variables that they are measured with a numeric value, e.g. duration (measured in minutes).
2. The independent variable consists of two categorical, dependent groups. This are related groups, or the pairs are matched. By related groups, the subjects are presented in both groups. Both groups are measured twice, which is also called a cross over design. By matched pairs, an observation from one testing group matches with the observation of the other testing group (Almukkahal et al., 2019).
3. The distributions of the differences between the two related groups are symmetrical in shape. This is the case when the mean, median and mode occur at the same point (Chen, 2019).

Calculations

The sample has a total size of N, this means that there are N pairs, with a total of 2N observations. One pair is stated as $x_{1,i}$ and $x_{2,i}$ (with $i = 1, \ldots, N$). With the Wilcoxon signed-rank test the difference between the pairs is calculated first. This is calculated by $x_{2,i} - x_{1,i}$ (for $i = 1, \ldots, N$). Then, one takes all the absolute values of the differences. Any zero values are deleted from the sample. The rest is awarded with ranks, starting from the lowest absolute difference to the highest one. When all pairs have a rank, the rank-sum T- and rank-sum T+ are calculated. For T-, this the sum of the ranks from the pairs that have a negative difference, and for T+, this is the sum of ranks from the pairs that have a positive difference. The lowest value of both T- and T+ is the W_{stat} value (O'Loughlin, 2017).

To see whether there is a significant difference between the pairs, the W_{stat} must be equal or smaller than the critical value W_{crit} from the table, see Appendix B.2. If this is the case, one can reject the null hypothesis (O'Loughlin, 2017). This method must be used for samples smaller than 10 pairs (N<10) and can be used to a maximum sample size of 25 pairs (N≤25)(Lowry, 2020).

When the sample size increases, the distribution converges into a normal distribution. This is the case if N≥10 (Lowry, 2020). The z-score is calculated as:

$$z = \frac{W_{stat}}{\sigma_W} \tag{7}$$

With:

$$\sigma_W = \sqrt{\frac{N\ (N+1)(2N+1)}{6}} \tag{8}$$

The null hypothesis is rejected when $z_{crit} < |z|$, which indicates that a difference between the two pairs is unlikely to occur with a 95% confidence interval, if $\alpha = 0.05$. For the value of z_{crit}, see Appendix B.3.

Usage in literature

In literature, the method is used to measure efficiency. One of the studies is from Joda and Brägger (2015). They used the Wilcoxon signed-rank test to analyse the cost/time efficiency of an implant-supported single-unit reconstruction in the digital workflow compared to the conventional pathway.

They made use of a crossover study design, with a sample size of 20 pairs (N=20), eventually showing that the digital workflow is more cost-efficient than the conventional pathway (Joda & Brägger, 2015).

5.2.4 Mann-Whitney U test

The Mann-Whitney U test, also known as the Wilcoxon rank-sum test, is a non-parametric test. It compares the mean of two populations with two random independent samples (Meijer, 2018). With the null hypothesis: "There is no difference between the ranks of each sample", versus the alternative hypothesis: "There is a difference between the ranks of each sample".

Assumptions

Before one can use the Mann-Whitney U test to analyse the data, the data should be checked whether it is sufficient to analyse it with the test. There are four different assumptions the data needs to fulfil, to use the test and get a valid result. Even when one or more of the assumptions is not met, there is often another solution for it (Laerd Statistics, 2013). The four assumptions are:

1. The dependent variable is either measured at the ordinal level or at the continuous level. For ordinal variables this means that they are measured in scales or categories, and for continuous variables that they are measured with a numeric value, e.g. duration (measured in minutes).
2. The independent variable consists of two categorical, independent groups. This is for example the case when one group is treatment 'A' and the other group is treatment 'B'.
3. The observations are independent of each other. The dependency of samples is explained before in this chapter. If the study data is not independent of each other, the Wilcoxon signed-rank test can be used.
4. The distributions of both groups of the independent variables have the same (or a 'similar') shape, which is not normally distributed.

Calculations

The test is used for either small samples or large samples. In the cases of small samples, which have a total size smaller than 40 (n_1<20 or n_2<20), the distribution is tabulated. While, an approximation of the normal distribution is often used for sufficiently large samples (Meijer, 2018).

For comparing small samples, each observation is awarded a rank between 1 and $n_1 + n_2 = N$ from smallest to largest (Meijer, 2018). When an observation has the same value, the sum of the rank is divided by the number of observations with the same value. Both observations are then awarded with that average rank. After all the observations have a rank, the ranks for the observations of sample 1 (R_1) can be add up, and the same goes for the ranks for the observations of sample 2 (R_2).

$$R_1 = \sum_i X_i \tag{9}$$

Then U_1 is given as:

$$U_1 = R_1 - \frac{n_1(n_1+1)}{2} \tag{10}$$

Calculating U_2 in the same way but use sample two instead. The null hypothesis is rejected if, the smallest number out of the both obtained *U* values is smaller than the critical value *U* from the table (Appendix B.1), which indicates a significant difference in the ranks of both samples. The critical *U* value is determined by the numbers n_1 and n_2 and by the error level of significance *a (O'Loughlin, 2016).*

For comparing relatively larger samples, *U* is approximately normally distributed. The rule of thumb for applying this normal approximation is: $n_1>5$ and $n_2>5$. Also, the samples are not bigger than 40 ($n_1<40$ or $n_2<40$) (Meijer, 2018). In the case of an approximately normal distribution, the standardized value is given by:

$$z = \frac{U - m_u}{\sigma_u} \quad (11)$$

With:

$$m_u = \frac{n_1 n_2}{2} \quad (12)$$

$$\sigma_u = \sqrt{\frac{n_1 n_2 (n_1 + n_2 + 1)}{12}} \quad (13)$$

Where m_u is the mean and σ_u is the standard deviation of *U*. When more than 20% of the observations in the samples are tied (Meijer, 2018), the standard deviation is corrected to:

$$\sigma_{corr} = \sqrt{\frac{1}{12} \cdot \frac{n_1 n_2 (N^3 - \sum_j t_j^3)}{N(N-1)}} \quad (14)$$

Where N is the total sample size ($n_1 + n_2$), t_j is the number of observations in tie *j*.

Usage in literature

In literature, Joda and Brägger (2016) have used the test to analyse the time-efficiency of a treatment with implant crowns made of monolithic lithium disilicate (LS2) plus titanium base, versus porcelain fuse to zirconium dioxide (ZrO2) in a digital workflow. In the study, they used a sample size of 20 study participants. After randomization, ten patients were restored as the test group and the other ten patients were restored as the control group. The total process time of an implant was measured in minutes, adding clinical plus laboratory work steps. Statistical analysis shows that the digital workflow seems to be more time-efficient than the established conventional production pathway for fixed implant-supported crowns (Joda & Brägger, 2016). Both the clinical chair time and laboratory manufacturing steps were reduced with the digital process.

5.2.5 Statistical tests conclusion

In 2015, Joda & Brägger used the Mann-Whitney U test to compare the cost-efficiency of two processes (see Usage in literature). This indicates that both the Wilcoxon signed-rank test and the Mann-Whitney U test can be used to compare the efficiency of two processes when it concerns a non-normal distribution. Depending on the dependency of the sample, one test is chosen. While the student t-test is chosen, when a normal distribution is assumed. Either the dependent t-test or independent t-test is selected, which depends on the dependency of the samples.

6. Testing and results

This chapter outlines the analyses of the processes at the general practice centre with Spreekuur. To do this, first, the processes are chosen. Then, the right statistical analysing method, out of the outlined methods in Chapter 5, is determined per processes. After that, the results from the tests are analysed. These results should indicate the efficiency of Spreekuur for general practices.

The different activities that occur with the implementation of Spreekuur have corresponding data sets that are analysed within this chapter. Also, the reason why these sets are chosen is explained. Chapter 3 already indicates that employee costs (72.6%) and housing location costs (10.7%) cover the biggest portion of the total costs. The time-efficiency of Spreekuur is important when it comes to employee costs. For the housing locations costs, the number of patients' visits at the general practice centre is crucial. Therefore, for both, the employee costs and the housing location costs, different data sets are analysed by the corresponding analysing method.

6.1 Patients' visits

With the implementation of Spreekuur at a general practice centre, the number of patients' visits should decrease because a part of the physical consultations is replaced by Spreekuur consultations. A decrease in the number of physical consultations leads to fewer rooms at the general practice, which decreases the housing locations costs. This is analysed but before that is possible, the data sets must be determined first. The aim is to analyse these with the dependent t-test because it is used to test on the mean difference between of two samples, which in this case are two dependent samples. After the data sets are determined, it is checked whether the dependent t-test is the right analysing method for this scenario. This is done by following the steps from Chapter 5.

Data sets and analysing method

For the analysis, two samples are used that must fulfil the assumptions from Chapter 5. Both data sets are, thus, measured at a continuous scale. The observations are the number of consultations per day, and are, therefore, numeric because they are integers. Furthermore, the samples are dependent because it concerns the same independent variable but for a different period. The observations are the number of consultations per day, and are, therefore, numeric because they are integers. Furthermore, both samples concern the same independent variable but for a different period, which makes them dependent samples. The first sample contains the number of physical consultations at the general practice centre for a given period from before the implementation of Spreekuur, and the other sample contains the number of physical consultations at the general practice centre with the implementation of Spreekuur for a given period. This given period is the same for both data sets, otherwise, the results are not valid. Therefore, the observations in the data sets are from the same month but another year. In this case, this means that one data set contains observations from 2019, and the other data set contains observations from 2020. When the period is determined, significant outliers in the difference between the two related groups are removed. There is a significant difference in the number of physical consultations for a day in the weekend, and the number for an evening during the week. Therefore, a pair of observations is only possible when it concerns the same day of the week. Furthermore, the compared samples are both observations during the week or observations during the weekend. Fulfilling the three assumptions, with the available data, it leads to the two samples in Table 9 for consultations in the evening during the week and the two samples of Table 910 for consultations in the weekend. Where n_i indicates the same day in the week in the same month, but in another year, for both samples. This means that in Table 9, n_1 is a Monday in May 2019 for the first sample and n_1 is a Monday in May 2020 for the second sample.

Table 9: Samples with the number of physical consultations per day during the week

n	Before the implementation of Spreekuur	With the implementation of Spreekuur
1	67	37
2	70	42
3	60	31
4	70	36
5	74	39
6	61	40
7	60	33
8	72	44
9	60	30
10	64	49
11	62	50
12	85	54
13	72	56
14	72	40
15	55	42
16	62	40
17	85	59

Table 10: Samples with the number of physical consultations per day in the weekend

n	Before the implementation of Spreekuur	With the implementation of Spreekuur
1	246	130
2	201	150
3	284	129
4	272	109
5	232	157
6	190	126
7	256	152
8	204	128
9	250	172
10	185	124
11	266	140
12	217	110
13	271	178
14	240	127

The last step is to check whether the distribution of the differences between the two pairs is approximately normally distributed. When this is the case, the dependent t-test is used to test on the data. First, the differences between the data from Table 9 are calculated. Then, a descriptive statistical analysis is executed in SPSS, which leads to Table 11. This table provides the most important values of the data.

Table 11: Descriptive statistical analysis of the difference in the number of evening consultations

	Mean	Standard error of the mean	Median	Standard Deviation	Kurtosis	Skewness
Difference in evening consultations	25.2353	1.79158	28.0000	7.38689	-0.864	-0.650

The mean difference between the number of consultations before the implementation of Spreekuur and the number with Spreekuur is 25.2353. This means that there are fewer physical consultations with Spreekuur, with a confidence interval (95%) between 21.4373 and 29.0333. Furthermore, the values of kurtosis and skewness are important to determine normality. When both are between -1 and 1, it is the first indication of a normality distribution. After the descriptive statistic analysis, the normality check is executed in SPSS, see Table 12.

Table 12: Shapiro-Wilk test on normality for the difference in the number of evening consultations

	Statistic	df	Statistical Significance
Difference in evening consultations	0.905	17	0.083

When the value of the Statistical Significance is larger than 0.05, it means that one cannot reject the null hypothesis of normality, which means that the dependent t-test can be used on the data set of the number of consultations in the evening during the week.

This last step is also executed to determine whether the dependent t-test is approved to use on the data set of Table 10. The mean difference between the number of consultations before the implementation of Spreekuur and the number with Spreekuur is 98.7143, for the consultations in the weekend. This means that there are fewer physical consultations with Spreekuur, with a confidence interval (95%) between 79.0436 and 118.3850. Furthermore, the skewness and kurtosis value are 0.533 and -0.459, respectively, which is the first indication of normality. The data is checked with the Shapiro-Wilk test to confirm normality, giving a Statistical Significance value of 0.530. Therefore, the null hypothesis of normality is not rejected, indicating that the dependent t-test can be used for this data set as well. Tables from the descriptive statistical analysis and the normality test of the data set in SPSS are found in Appendix C: Test results number of physical consultations in the weekend.

Results

Now it is clear that the data fulfil all the assumptions to analyse it with the dependent t-test, the method is executed in SPSS with the corresponding data. Table 13 shows the results of both tests.

Table 13: Dependent t-test on the number of consultations

	Mean	**Standard Deviation**	**Standard Error of the mean**	**Confidence interval (95%) – Lower bound**	**Confidence Interval (95%) – Upper bound**	**T**	**df**	**Statistical Significance (2-tailed test)**
Consultations in the evening during the week	25.235	7.387	1.792	21.437	29.033	14.085	16	0.000
Consultations in the weekend	98.71429	34.06877	9.10526	79.04356	118.38501	10.841	13	0.000

One can detect a big difference in the mean of both groups, because the value is not close to zero in both cases. Also, the values of the lower and upper bound of the confidence interval are positive. When zero is not within both lower and upper bound, the null hypothesis is likely to be rejected. For consultations in the evening during the week, the T value is 14.085, which is larger than the critical value of 2.120. And for consultations in the weekend, the T value is 10.841, which is larger than the critical value of 2.160. Therefore, the statistical significance is lower than 0.05, which means that the null hypothesis is rejected in both cases, indicating that the mean difference of the paired groups is not zero.

The overall number of consultations is, therefore, less in the period with the use of Spreekuur at the general practice centre. In evenings during the week, there were 35.4% less physical consultations, and, in the weekend, there were 41.7% less physical consultations, compared to the period without Spreekuur. For the housing location, there must be enough space for the general practitioners at the peak periods. When there are fewer consultations at the peak periods, then the number of rooms at the housing location can be less. An approximation of the number of saved rooms by fewer physical consultations is made by interviewing a general practitioner, see Table 14.

Table 14: Number of rooms at a general practice centre depending on the number of physical consultations

Physical consultations	Rooms at the general practice centre
10% less	Same number of rooms
15% less	1 less room
20% less	1 less room
25% less	2 fewer rooms
30% less	2 fewer rooms

For this research, it means that the concerned general practice centre can have at least two fewer rooms because the mean difference is 41.7%. This is a general approximation of the number of saved rooms, where the saved costs depend on the housing location. To get more precise results about the costs savings, it is, therefore, important to measure the decrease in the number of consultations at the general practice with the corresponding costs per room. Also, the decrease in the number of physical consultations must be a result of the use of Spreekuur. Therefore, the total number of all consultations, which includes physical consultations, telephone consultations, digital consultations (Spreekuur) and visit consultations, is approximately the same in the period of both samples. In addition to that, the difference in physical consultations should be replaced by an increased number of Spreekuur consultations.

Due to the coronavirus the total number of all consultations was not approximately the same for both periods. The coronavirus has such an impact on the number of physical consultations because people should stay at home during this period. Therefore, it cannot be concluded that the number is decreased by the implementation of Spreekuur.

6.2 Time-efficiency

To see, whether Spreekuur is more time-efficient than other forms of consultation, indicating that the general practitioner can help more patients, data sets and analysing method must be determined first. The aim is to analyse the data with the Mann-Whitney U test because it can be used with a relatively small sample size ($n1<40$ or $n2<40$). To use the test, the data sets have to fulfil the assumptions of the test, which is done by following the steps explained in Chapter 5. When this is the case, the test is used for the analysis of the data.

Data sets and analysing method

For the analysis, it is important to know what one wants to compare. In this case, it is the time-efficiency of Spreekuur compared to the other forms of regular consultations at the general practice centre, which are physical consultations and telephone consultations. All these forms are covered in Chapter 2 in more detail. To compare the time-efficiency of the different consultation forms, the whole care process is taken into account. This means that, from, the first moment the patient gets in contact with the general practice until the end moment, should be measured. Only the time, from, the moments that the care provider is busy with the care process of the patient should be measured. Therefore, the patient's waiting time and the patient's transport time are excluded from the total duration. One care process consists of the following moments:

- Triage between triagist and patient.
- Registration of the patient.
- Reception at the general practice.
- Preparations of the care provider before the consultation.

- Consultation between the care provider and the patient.
- Registration of the patient.

These moments are all measured for the different consultation forms in minutes, with the sum of all moments for one patient as one observation. Therefore, the duration is the dependent variable measured in minutes, and the consultation form is the independent variable. Table 15 contains the description of how an observation of the care process should look like, for all three consultation forms. Multiple observations are one sample. This data must fulfil the corresponding assumptions of the Mann-Whitney U test. First, the data should be independent of each other. Therefore, the care processes of the patients that are measured are randomly selected. Also, both samples cannot contain the same patient, which also prevents observations of patients that go through multiple consultations. This happens when a patient has a telephone or Spreekuur consultation, but still needs to go to the general practice because the general practitioner wants to see the patient's health complaint. Secondly, the data has no specific distribution.

The data currently available are not valid to analyse for several reasons. First, since March 2020, some steps in the care process can take longer than before due to the coronavirus. These steps are the triage between the triagist and the patient, the reception at the general practice, and the consultation between the care provider and the patient. Secondly, the consultation duration in the current data only has a start and end time, instead of the effective time. This can result in longer consultation durations because a consultation could already have been finished half an hour before the general practitioner enters the data into the system. Lastly, in the current data, the registration of patients is not considered, while they should because this can be different per consultation form and, therefore, affect the total duration of the care process.

Table 15: Description of the duration of the care process per regular consultation form

Physical consultation	**Telephone consultation**	**Spreekuur consultation**
Triage	Triage	
Registration of patient	Registration of patient	
Reception at the general practice		
Checks health complaint of the patient in the system to prepare the consultation	Checks health complaint of the patient in the system to prepare the consultation	Checks health complaint of the patient in the chat function before replying
The consultation	The consultation	Every time the general practitioner opens the chat with the patient (the consultation)
Registration of patient	Registration of the patient	Registration of the patient

Results

When the data are available, they can be analysed with the Mann-Whitney U test. Therefore, the data should first meet the assumptions, which one can check by following the steps from section 5.2.4 Mann-Whitney U test. When the data do meet the assumptions, one selects two samples to test. Results from the tests show whether the duration of a care process with the corresponding consultation form is significantly faster than the other one. Regarding Table 15, the care process with the use of a Spreekuur consultation should be more time-efficient because there are less steps to measure. The triage between the triagist and the patient, and the registration of it, takes on average between the 7.5 and 9.5 minutes, see Appendix A. Therefore, it is in theory faster than the care processes with other consultation forms.

7. Conclusion, recommendations, and discussion

This chapter outlines the main findings of this thesis. In the conclusion section the answer to the main research question is drawn. Then, recommendations for Topicus about the funding and cost-efficiency of Spreekuur are given. This also includes the framework of statistical methods that are most used in a medical context and how to use, the most applicable ones, for the cost-efficiency analysis of Spreekuur. After that, the shortcomings of this thesis are outlined. These might be interesting for further research.

7.1 Conclusion

To conclude this thesis, an answer to the main research question is given. This question is: *Which requirements should the funding model for Spreekuur have such that it provides relevant information for primary care providers, taken different scenarios into account?*

By implementing Spreekuur at a general practice, they can increase their income and decrease their costs. One way to generate income is the execution of consultations. With Spreekuur, a general practitioner can have more consultations. Also, they can get result rewards for using it, for an even higher income generation. However, they both depend on the made agreements between the general practice and the health insurance company. This means that the actual income can be lower than expected. Therefore, it is most important to decrease the costs of general practices with the implementation of Spreekuur. This can be done by decreasing employee costs and housing locations costs. An analysis of the data must show whether that is the case. To ensure valid results from the tests, the data sets must meet certain assumptions. Therefore, situations have been outlined, regarding the data of the time-efficiency and the decrease of patient's visits, and the corresponding analysing methods. Furthermore, it has been explained how these methods, and other common methods, can be used in a medical context. As a result, this framework of statistical methods can also be applied to analyse other products, functions, or systems in the future.

7.2 Recommendations

In this section, my recommendations about the requirements of the funding of Spreekuur are given to Topicus. For Spreekuur to be cost-efficient, the application must decrease the costs at a general practice. These are employee costs and housing location costs.

To decrease employee costs, the application must be more time-efficient than other consultation forms. To analyse this, I recommend using the Mann-Whitney U test, which compares the mean of two populations with two random independent samples. Another option to decrease employee costs is obtained when doctor's assistants can do consultations with Spreekuur because they are less expensive than general practitioners.

To decrease the housing locations costs, the application must lead to fewer consultations at the general practice. For physical consultation, the patient comes to the general practice, where a certain number of rooms must be rent. To analyse a decrease in the number of physical consultations, I recommend using the dependent t-test, which tests on the mean difference of two paired samples.

The application could also increase the income of general practices. Therefore, the general practice must make agreements about rewarding the results for 'service and accessibility' and 'stimulation of practitioner care in shrinking regions'.

7.3 Discussion

The main goal of this thesis was to create a funding model for Spreekuur. Also, Topicus would like to get an overview of the current financial situation within primary healthcare regarding developments and innovations. For them, it is useful to see how Spreekuur would fit into a new situation and how other products and systems could be improved or created.

By interviewing stakeholders, testing on efficiency and literature search, it was not possible to create a funding model for Spreekuur, therefore, recommendations for the model are created instead. With as main reason the validity of the data, which was influenced by the coronavirus. The data would be used to measure the time-efficiency of Spreekuur and the patient's visits at the general practice. When Spreekuur has a positive effect on them, it leads to a decrease in the costs of the general practice. However, there is only data about Spreekuur, available since March 2020 because this was the first time the application was used in practice. In this period, people were advised to stay at home and extra measures were taken to prevent the spread of the virus. This possibly affected the number of physical consultations and the duration of triages and consultations. Therefore, recommendations about the analysis methods for the corresponding scenario were given to Topicus. When the data is valid in the future, they can use these recommendations for the analysis.

Furthermore, this thesis indicates the possible income increase that Spreekuur occurs at a general practice. Currently, these numbers are still vague as the application is still in the starting phase. Also, the tariff for the result rewards depends on the agreements the general practice makes with the health insurance company, which is different for every general practice.

Therefore, further research needs to be done into the impact of Spreekuur at a specific general practice. For that research, all relevant information for the funding must be made available by the general practice. This includes information like housing location costs and employee costs with the corresponding numbers of both. It is also useful to visit the location of the general practice, which creates a good overview of the situation and helps by creating the funding model of Spreekuur. Whereby, this thesis can be used as a basis for further research.

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Appendix A: Visit consultations and triage duration

Maximum tariff for visit consultations (NZa, 2019)

Visit consultation duration	Maximum tariff
Less than 20 minutes	€15.22
Longer than 20 minutes	€25.37

Average duration of the triage between the triagist and the patient, and the registration of it.

Appendix B: Tables for critical values

Appendix B.1

Table of the critical values for the Mann-Whitney U test (University of Saskatchewan, n.d.).

Table A5.07: Critical Values for the Wilcoxon/Mann-Whitney Test (U)

Nondirectional α=.05 (Directional α=.025)

	n_2																			
n_1	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2	-	-	-	-	-	-	-	0	0	0	0	1	1	1	1	1	2	2	2	2
3	-	-	-	-	0	1	1	2	2	3	3	4	4	5	5	6	6	7	7	8
4	-	-	-	0	1	2	3	4	4	5	6	7	8	9	10	11	11	12	13	13
5	-	-	0	1	2	3	5	6	7	8	9	11	12	13	14	15	17	18	19	20
6	-	-	1	2	3	5	6	8	10	11	13	14	16	17	19	21	22	24	25	27
7	-	-	1	3	5	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34
8	-	0	2	4	6	8	10	13	15	17	19	22	24	26	29	31	34	36	38	41
9	-	0	2	4	7	10	12	15	17	21	23	26	28	31	34	37	39	42	45	48
10	-	0	3	5	8	11	14	17	20	23	26	29	33	36	39	42	45	48	52	55
11	-	0	3	6	9	13	16	19	23	26	30	33	37	40	44	47	51	55	58	62
12	-	1	4	7	11	14	18	22	26	29	33	37	41	45	49	53	57	61	65	69
13	-	1	4	8	12	16	20	24	28	33	37	41	45	50	54	59	63	67	72	76
14	-	1	5	9	13	17	22	26	31	36	40	45	50	55	59	64	67	74	78	83
15	-	1	5	10	14	19	24	29	34	39	44	49	54	59	64	70	75	80	85	90
16	-	1	6	11	15	21	26	31	37	42	47	53	59	64	70	75	81	86	92	98
17	-	2	6	11	17	22	28	34	39	45	51	57	63	67	75	81	87	93	99	105
18	-	2	7	12	18	24	30	36	42	48	55	61	67	74	80	86	93	99	106	112
19	-	2	7	13	19	25	32	38	45	52	58	65	72	78	85	92	99	106	113	119
20	-	2	8	14	20	27	34	41	48	55	62	69	76	83	90	98	105	112	119	127

Nondirectional α=.01 (Directional α=.005)

	n_2																			
n_1	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	0
3	-	-	-	-	-	-	-	-	0	0	0	1	1	1	2	2	2	2	3	3
4	-	-	-			0	0	1	1	2	2	3	3	4	5	5	6	6	7	8
5	-	-	-		0	1	1	2	3	4	5	6	7	7	8	9	10	11	12	13
6	-	-	-	0	1	2	3	4	5	6	7	9	10	11	12	13	15	16	17	18
7	-	-	-	0	1	3	4	6	7	9	10	12	13	15	16	18	19	21	22	24
8	-	-	-	1	2	4	6	7	9	11	13	15	17	18	20	22	24	26	28	30
9	-	-	0	1	3	5	7	9	11	13	16	18	20	22	24	27	29	31	33	36
10	-	-	0	2	4	6	9	11	13	16	18	21	24	26	29	31	34	37	39	42
11	-	-	0	2	5	7	10	13	16	18	21	24	27	30	33	36	39	42	45	46
12	-	-	1	3	6	9	12	15	18	21	24	27	31	34	37	41	44	47	51	54
13	-	-	1	3	7	10	13	17	20	24	27	31	34	38	42	45	49	53	56	60
14	-	-	1	4	7	11	15	18	22	26	30	34	38	42	46	50	54	58	63	67
15	-	-	2	5	8	12	16	20	24	29	33	37	42	46	51	55	60	64	69	73
16	-	-	2	5	9	13	18	22	27	31	36	41	45	50	55	60	65	70	74	79
17	-	-	2	6	10	15	19	24	29	34	39	44	49	54	60	65	70	75	81	86
18	-	-	2	6	11	16	21	26	31	37	42	47	53	58	64	70	75	81	87	92
19	-	0	3	7	12	17	22	28	33	39	45	51	56	63	69	74	81	87	93	99
20	-	0	3	8	13	18	24	30	36	42	46	54	60	67	73	79	86	92	99	105

U_{obt} is the lesser of the two calculated test statistics (U_1 & U_2). If $U_{obt} \le U_{crit}$, reject H_0.
Dashes (-) indicate that the sample size is too small to reject the Null Hypothesis at the chosen α level.

If n > 20 this table cannot be used. A **p** can be computed for U_{obt}, using the normal distribution approximation:

$$z_U = \frac{\left| U_{obt} - \left(\frac{n_1 n_2}{2} \right) \right|}{\sqrt{\frac{n_1 n_2 (n_1 + n_2 + 1)}{12}}}$$

Appendix B.2

Table of critical values for the Wilcoxon test (University of Sussex, 2005).

Table of critical values for the Wilcoxon test:

To use this table: compare your obtained value of Wilcoxon's test statistic to the critical value in the table (taking into account N, the number of subjects). Your obtained value is statistically significiant if it is equal to or SMALLER than the value in the table.

e.g.: suppose my obtained value is 22, and I had 15 participants. The critical value in the table is 25: my obtained value is *smaller* than this, and so I would conclude that the difference between the two conditions in my study was unlikely to occur by chance (p<.05 two-tailed test, or p<.025, one-tailed test).

	One Tailed Significance levels:		
	0.025	**0.01**	**0.005**
	Two Tailed significance levels:		
N	**0.05**	**0.02**	**0.01**
6	0	-	-
7	2	0	-
8	4	2	0
9	6	3	2
10	8	5	3
11	11	7	5
12	14	10	7
13	17	13	10
14	21	16	13
15	25	20	16
16	30	24	20
17	35	28	23
18	40	33	28
19	46	38	32
20	52	43	38
21	59	49	43
22	66	56	49
23	73	62	55
24	81	69	61
25	89	77	68

Appendix B.3

Table of the critical values of *z* (Lowry, 2020).

Critical Values of ±z

Level of Significance for a				
Directional Test				
.05	**.025**	**.01**	**.005**	**.0005**
Non-Directional Test				
--	**.05**	**.02**	**.01**	**.001**
$z_{critical}$				
1.645	1.960	2.326	2.576	3.291

Appendix B.4

Critical values t-distribution table (San José State University, 2007).

t Table

cum. prob	$t_{.50}$	$t_{.75}$	$t_{.80}$	$t_{.85}$	$t_{.90}$	$t_{.95}$	$t_{.975}$	$t_{.99}$	$t_{.995}$	$t_{.999}$	$t_{.9995}$
one-tail	**0.50**	**0.25**	**0.20**	**0.15**	**0.10**	**0.05**	**0.025**	**0.01**	**0.005**	**0.001**	**0.0005**
two-tails	**1.00**	**0.50**	**0.40**	**0.30**	**0.20**	**0.10**	**0.05**	**0.02**	**0.01**	**0.002**	**0.001**
df											
1	0.000	1.000	1.376	1.963	3.078	6.314	12.71	31.82	63.66	318.31	636.62
2	0.000	0.816	1.061	1.386	1.886	2.920	4.303	6.965	9.925	22.327	31.599
3	0.000	0.765	0.978	1.250	1.638	2.353	3.182	4.541	5.841	10.215	12.924
4	0.000	0.741	0.941	1.190	1.533	2.132	2.776	3.747	4.604	7.173	8.610
5	0.000	0.727	0.920	1.156	1.476	2.015	2.571	3.365	4.032	5.893	6.869
6	0.000	0.718	0.906	1.134	1.440	1.943	2.447	3.143	3.707	5.208	5.959
7	0.000	0.711	0.896	1.119	1.415	1.895	2.365	2.998	3.499	4.785	5.408
8	0.000	0.706	0.889	1.108	1.397	1.860	2.306	2.896	3.355	4.501	5.041
9	0.000	0.703	0.883	1.100	1.383	1.833	2.262	2.821	3.250	4.297	4.781
10	0.000	0.700	0.879	1.093	1.372	1.812	2.228	2.764	3.169	4.144	4.587
11	0.000	0.697	0.876	1.088	1.363	1.796	2.201	2.718	3.106	4.025	4.437
12	0.000	0.695	0.873	1.083	1.356	1.782	2.179	2.681	3.055	3.930	4.318
13	0.000	0.694	0.870	1.079	1.350	1.771	2.160	2.650	3.012	3.852	4.221
14	0.000	0.692	0.868	1.076	1.345	1.761	2.145	2.624	2.977	3.787	4.140
15	0.000	0.691	0.866	1.074	1.341	1.753	2.131	2.602	2.947	3.733	4.073
16	0.000	0.690	0.865	1.071	1.337	1.746	2.120	2.583	2.921	3.686	4.015
17	0.000	0.689	0.863	1.069	1.333	1.740	2.110	2.567	2.898	3.646	3.965
18	0.000	0.688	0.862	1.067	1.330	1.734	2.101	2.552	2.878	3.610	3.922
19	0.000	0.688	0.861	1.066	1.328	1.729	2.093	2.539	2.861	3.579	3.883
20	0.000	0.687	0.860	1.064	1.325	1.725	2.086	2.528	2.845	3.552	3.850
21	0.000	0.686	0.859	1.063	1.323	1.721	2.080	2.518	2.831	3.527	3.819
22	0.000	0.686	0.858	1.061	1.321	1.717	2.074	2.508	2.819	3.505	3.792
23	0.000	0.685	0.858	1.060	1.319	1.714	2.069	2.500	2.807	3.485	3.768
24	0.000	0.685	0.857	1.059	1.318	1.711	2.064	2.492	2.797	3.467	3.745
25	0.000	0.684	0.856	1.058	1.316	1.708	2.060	2.485	2.787	3.450	3.725
26	0.000	0.684	0.856	1.058	1.315	1.706	2.056	2.479	2.779	3.435	3.707
27	0.000	0.684	0.855	1.057	1.314	1.703	2.052	2.473	2.771	3.421	3.690
28	0.000	0.683	0.855	1.056	1.313	1.701	2.048	2.467	2.763	3.408	3.674
29	0.000	0.683	0.854	1.055	1.311	1.699	2.045	2.462	2.756	3.396	3.659
30	0.000	0.683	0.854	1.055	1.310	1.697	2.042	2.457	2.750	3.385	3.646
40	0.000	0.681	0.851	1.050	1.303	1.684	2.021	2.423	2.704	3.307	3.551
60	0.000	0.679	0.848	1.045	1.296	1.671	2.000	2.390	2.660	3.232	3.460
80	0.000	0.678	0.846	1.043	1.292	1.664	1.990	2.374	2.639	3.195	3.416
100	0.000	0.677	0.845	1.042	1.290	1.660	1.984	2.364	2.626	3.174	3.390
1000	0.000	0.675	0.842	1.037	1.282	1.646	1.962	2.330	2.581	3.098	3.300
z	0.000	0.674	0.842	1.036	1.282	1.645	1.960	2.326	2.576	3.090	3.291
	0%	50%	60%	70%	80%	90%	95%	98%	99%	99.8%	99.9%
	Confidence Level										

Appendix C: Test results number of physical consultations in the weekend

Table of the descriptive statistical analysis on the difference in the number of physical consultations in the weekend.

Descriptives

			Statistic	Std. Error
Difference weekend consultations	Mean		98,7143	9,10526
	95% Confidence Interval for Mean	Lower Bound	79,0436	
		Upper Bound	118,3850	
	5% Trimmed Mean		97,7937	
	Median		98,5000	
	Variance		1160,681	
	Std. Deviation		34,06877	
	Minimum		51,00	
	Maximum		163,00	
	Range		112,00	
	Interquartile Range		46,25	
	Skewness		,533	,597
	Kurtosis		-,459	1,154

Table of the normality test on the difference in the number of physical consultations in the weekend.

Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Difference weekend consultations	,157	14	,200*	,948	14	,530

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction