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**Service process for diabetic nurse
when using handheld infrared
thermal imaging**

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<p>Foot ulcers are unwelcome complication of diabetes and early detection is crucial when treating and finding foot ulcers. Modern welfare technology offers a new tool to battle against diabetes complications. This new tool gives chance to measure foot skin temperature to identify people at risk of developing foot ulcers. Infrared thermal imaging (ITI) is finding it's route to be part of healthcare.</p> <p>This research was conducted to explore the way in which nurses and podiatrists (healthcare professionals) experience infrared thermal imaging in part of their daily work routines in the field of diabetic care. This study was conducted in a physiotherapy and rehabilitation services clinic which provides treatment and counseling to people with diabetes in the Uusimaa region in Finland.</p> <p>Purpose of this study was to provide service process for target company TherMidas and to their new handheld ITI-system using chosen service design approach.</p> <p>Service design approach included a market scan regarding different imaging services, TherMidas multidisciplinary team opinions and target healthcare professional's opinions.</p> <p>To gather the data from healthcare professionals, the researcher interviewed two healthcare professionals. Data was gathered with individual questionnaire and with thematic group interview. All data were analyzed using inductive content analysis.</p> <p>This research results concluded that real healthcare professionals experienced ITI to be beneficial tool in part to their work and in the treatment of diabetic feet. This research produced new service process for the handheld ITI-system and increased target company product assortment.</p>		
Keywords Infrared thermal imaging, service design development, diabetic care, welfare technology		

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1 INTRODUCTION

This subject, service process for diabetic nurse when using handheld infrared thermal imaging system, is focusing to explore the way in which nurses and podiatrists (healthcare professionals) experience ITI in part of their daily work routines in the field of diabetic care and what would be the best service process for the use of handheld ITI-system. The goal of this master's thesis is to provide clear service process for TherMidas company using chosen service design approach. This study is created as a qualitative study and data will be collected with individual questionnaire and thematic group interview made with focused healthcare professionals. New service process will be based on analyzed research results and opinions of TherMidas company professionals. This study took place in a physiotherapy and rehabilitation services clinic which provides treatment and counseling to people with diabetes in the Uusimaa region in Finland. The handheld ITI-system is a new innovation and there were no studies conducted about how healthcare professionals experience handheld ITI-system in part of their daily work routines in the field of diabetic care.

The development of an ITI system suitable for the imaging of a living object began in 2008 in Kemi and Rovaniemi. ITI equipment was initially used in animal imaging and it was found that the local temperature rise caused by inflammation could be imaged. Imaging of humans was started at Länsipohja Central Hospital and based on the initial observations the equipment was developed mainly in Rovaniemi and Kuopio to determine the optimal imaging methods and the normative nature of the images. Body heat is the earliest and most widely used biomarker for health. The first report on body heat originated from Hippocrates (460–377 BC), who used a cloth soaked in clay to compare the temperatures between healthy and diseased parts of the body based on the drying time of the clay. In the 1800s, the German astronomer William Herschel discovered infrared radiation, which is the cornerstone of modern non-invasive thermography. Molecules of every object emit infrared radiation (electromagnetic waves) as a result of their rotational-vibrational movements. That radiation is reflected and refracted like light and can be detected (Sippola 2021, 7-11).

The treatment of diabetes complications has evolved in past decades. Studying new methods of diabetic care is important to be able to renew and develop current care guidelines and improve diabetes complications. Early detection of diabetic ulcers is crucial in the treatment of diabetes. It is crucial to maintain the ability to live normal life with diabetes. The main thing is to prevent the disease progress and maintain the mobility of the patient. Other treatments don't see under the skin and ITI could help to save the patient ability to move or even a limb by detecting the advancing foot ulcer in the early phase. Diabetes is an expensive disease for society and early detection of the wounds can save also financial resources.

This research will gain advantage from the expertise and opinions of healthcare professionals who are working in the frontline of diabetes treatment. Research results are based on subjective experiences of target healthcare professionals regarding ITI informative materials and to their experience when using handheld ITI-system.

2 BENEFITS OF INFRARED THERMAL IMAGING FOR HEALTHCARE PROFESSIONAL COMPETENCE

2.1 Diabetes mellitus and complications

Diabetes mellitus is a disorder in which the level of blood glucose is persistently raised above the normal range. It occurs because of a lack of insulin, with or without factors that oppose the action of insulin. Diabetes mellitus was known in antiquity and remains today a worldwide and increasing health problem with a high cost from associated premature coronary artery disease, blindness, renal failure and amputations. The scientific basis of diabetes has evolved over centuries; it was long thought to be caused by kidney disease (Watkins, Amiel, Howell & Turner 2003, 3).

Three great pathologies come together in the diabetic foot: neuropathy, ischemia and infection. Their combined impact results in a swift progression to tissue necrosis, which is the fundamental hallmark of the natural history of the diabetic foot. Progress towards necrosis can be so rapid and devastating that it has come to be regarded as a

'diabetic foot attack', like the heart and brain attacks of the coronary and cerebrovascular systems. A 'diabetic foot attack' can quickly reach the point of no return, with overwhelming necrosis (Edmonds & Foster 2014, 1).

Foot ulcers are a frequent and costly complication of diabetes, with a lifetime incidence of the total health care expenditure on diabetes attributable to foot ulcers. Early detection and frequent assessment are the keys when treating and finding foot ulcers (Netten 2013, 1122-1123).

2.2 What is ITI?

Simple thermodynamic principles can explain the physics of infrared thermometry. All objects at a temperature greater than absolute zero release infrared radiation (IR). Similarly, in the human body, heat released by inflammation, fever, and infection is a form of infrared radiation. When a sensor perceives this infrared radiation in the infrared thermometer, the sensor converts this energy into a specific electrical signal that corresponds to a given temperature. The higher the temperature, the greater the infrared radiation received by the sensor, which displays a higher temperature reading (Sibbald 2015, 38-40).

With an algorithm based on parameters that can be captured and analyzed with a high-resolution infrared camera and a computer, it is possible to detect signs of diabetic foot disease for an individual with diabetes and to discriminate between no, local, or diffuse diabetic foot complications. As such, an intelligent telemedicine monitoring system for noninvasive automated detection of signs of diabetic foot disease is one-step closer like TherMidas system does. Future studies are essential to confirm and extend these promising early findings (Netten 2013, 1122).

Taking advantage of thermography will allow quick and easy detection of asymmetric body temperature indicating underlying pathologies, such as inflammation, circulatory issues and possible ulcerations. Abnormal body temperature is a natural indicator of illness. Diagnostic thermal imaging is a non-contact and non-invasive alternative to conventional imaging methods. Thermal Imaging can be used as a complementary

diagnostic method e.g. in orthopedics, occupational medicine, vascular medicine, oncology, rheumatic inflammation, trauma, post-operative or fracture pain, dentistry, and diabetic foot complications (TherMidas webpage 2022).

When using thermal imaging, the medical measurement result is based on three main factors: the thermal energy of the subject, the thermal transmittance of the tissues, and the measurement of reflections. The data captured by matrix technology is stored in a single file, and when analyzing thermal image data, the latest software automatically evaluates condition variables such as ambient and skin surface temperature, humidity, and imaging distance. The software uses an instantaneous or repeatedly measured emission range distribution of the imaging area to generate a thermal image and ambient temperature to determine the margin of error, as well as to determine the imaging distance. At least tens of thousands of different measurement points, readable even after electronic transmissions, can be included in the image itself. The type of temperature difference sought is entered into the software, after which the program automatically highlights these areas as visually detectable areas (ROI; region of interest) (Sippola 2021,9).

Temperature data is collected with either a thermal camera fixed on the trolley or a hand-held one, from which the data is downloaded to the ITI system via the camera's USB port. The information is stored in the TherMidas server's shared database if one is used. It is also possible to operate the system with a cart alone, in which case all data is stored exclusively in the cart database. Body heat is the oldest measure of health used in medicine. The ITI-system measures the thermal radiation of different tissues of the subject noninvasively from a distance of 1 to 5 m. The condition of tissues can be deduced from the surface temperature distribution emitted by a human (Sippola 2021,8).

The FLIR E96 is pistol-grip camera (Picture 1) with 640×480 thermal resolution. Healthcare professionals can survey targets safely and quickly diagnose patient. Interchangeable AutoCal™ lenses offer complete coverage of near and distant targets, with the laser distance meter ensuring the crisp focus needed for accurate temperature measurement. FLIR T560 (Picture 2) is 640×480 thermal resolution thermal imaging

camera has a bright 4" LCD and a 180° rotating lens platform, so user can easily and comfortably diagnose health issues, even in hard-to-reach areas (Flir webpage 2022).



Picture 1. FLIR E96 Professional Thermal Camera (Flir webpage 2022)



Picture 2. FLIR T560 Professional Thermal Camera (Flir webpage 2022)

2.3 Detection of diabetic wounds

Imaging of humans was started at Länsipohja Central Hospital and based on the initial observations the equipment was developed mainly in Rovaniemi and Kuopio to determine the optimal imaging methods and the normative nature of the images. Dual measurements were performed at the premises of VTT in Kuopio, where a separate measuring device was used to continuously measure the temperature of the skin surface with ten sensors during cold gel exposure and the result was compared with the dynamic information provided by the ITI equipment. Consistency of results encouraged the transition to clinical applications. The ITI equipment was tested e.g., in suspected skin and breast cancer, skin grafts, arthritis, limb ischemia of various causes in the evaluation of the effectiveness of vascular transplantation and especially after amputations in the assessment of the suitability of aids (Sippola 2021,7).

Measurement of foot skin temperatures is seen as a possible tool to identify people at risk of developing foot ulcer. The ability to detect clinically the initial signs of foot

ulcers may be limited, and pre-ulcerative inflammation can be missed during routine healthcare professional assessment (Petrova 2019, 95-103). Diabetic ulcers are met in different parts in the diabetic foot and sometimes the symptoms of the ulcers are not met with visible eye in full foot check. TherMidas is the only company, which has CE-labelled ITI-system in the world, and they offer certified education regarding their products (TherMidas company materials 2020). At each attendance at the diabetic clinic, the patient should have a full foot check. This must be done by the healthcare professional which is specialized to chronic wounds. Measurement of the ulcer by tracing may not provide adequate information as the surface area may not appear to alter greatly. A photographic record may be of more value (Dealey 2005, 159-162).

Petrova (2019) reported about multicenter clinical trial in which patients' feet were imaged with a novel ITI-system. Petrova's study consisted of an initial visit for screening and then monthly follow-up study visits for 1 year. Investigations at the screening visit included medical history, foot inspection, palpation of foot pulses, assessment of neuropathy and thermography. History of unilateral or bilateral foot ulcers and the number of previously healed foot ulcers were documented. Presence of deformity was recorded for each foot, and graded as no deformity, lesser toe deformities, prominent metatarsal heads, rocker bottom. Although the ulcer recurrence rate and ulcer-free survival were not significantly different between the intervention and the control groups, the present trial has informed the design of a refined study to further assess the relative efficacy of thermography (Petrova 2019, 97-103).

ITI is useful as an additional method for screening high-risk diabetic feet. Side-to-side and local temperature differences are a pathological sign. Diabetes-related neuropathy raises the skin temperature. An ulcer without clinical infection increases the skin temperature (Ilo, Pokela & Mäkelä 2020, 105).

It is important to focus on preventing the ulcers and locate the damage in the foot before it will escalate. Healthcare professional need to diagnose and react to the need of care based on the symptoms that the patient is or is not experiencing. To do so patient will need to visit clinic more frequently.

Healthcare professionals have based their evaluation to patient symptoms which are visible or can be detect in normal foot check. Current risk rating of diabetic legs are seen in Table 1. Lack of sense of feeling is examined with monofilament study. Blood supply is impaired if one or both of pulses of the feet is missing. Structure error is impaired if the patient foot is in wrong position comparing to normal. Previous wound or amputation is impaired if the patient had already experience amputation or severe wound. Basic guidance means the guidance of the diabetic feet, which can also be carried out in group guidance meetings. The need for visit to a healthcare professional is determined individually (Current Care Guidelines 2020).

Table 1. The risk rating of diabetic legs (Current Care Guidelines 2020). Translated Mikko Heino

<u>Risk class</u>	<u>Lack of sense of feeling</u>	<u>Structure error</u>	<u>Lack of pulses</u>	<u>Previous wound or amputation</u>	<u>Action</u>
0	NO	NO	NO	NO	<u>Inspection and risk classification</u> <u>Basic control</u>
1 Riski of wound double	YES 1	NO	NO	NO	<u>Inspection at least annually</u> <u>Basic control and self foot check</u> <u>Footwear control</u>
2 Riski of wound five times	YES	YES OR NO	YES OR NO	NO	<u>Regular visits with a podiatrist</u> <u>Self-care boost</u> <u>Inspection at the appointment</u> <u>Blood supply check</u>
3 Riski of wound over ten times	NOT	RELEVANT		YES 1	<u>Regular visits with a podiatrist</u> <u>Readiness to deal with leg problems</u> <u>Inspection at every appointment</u>

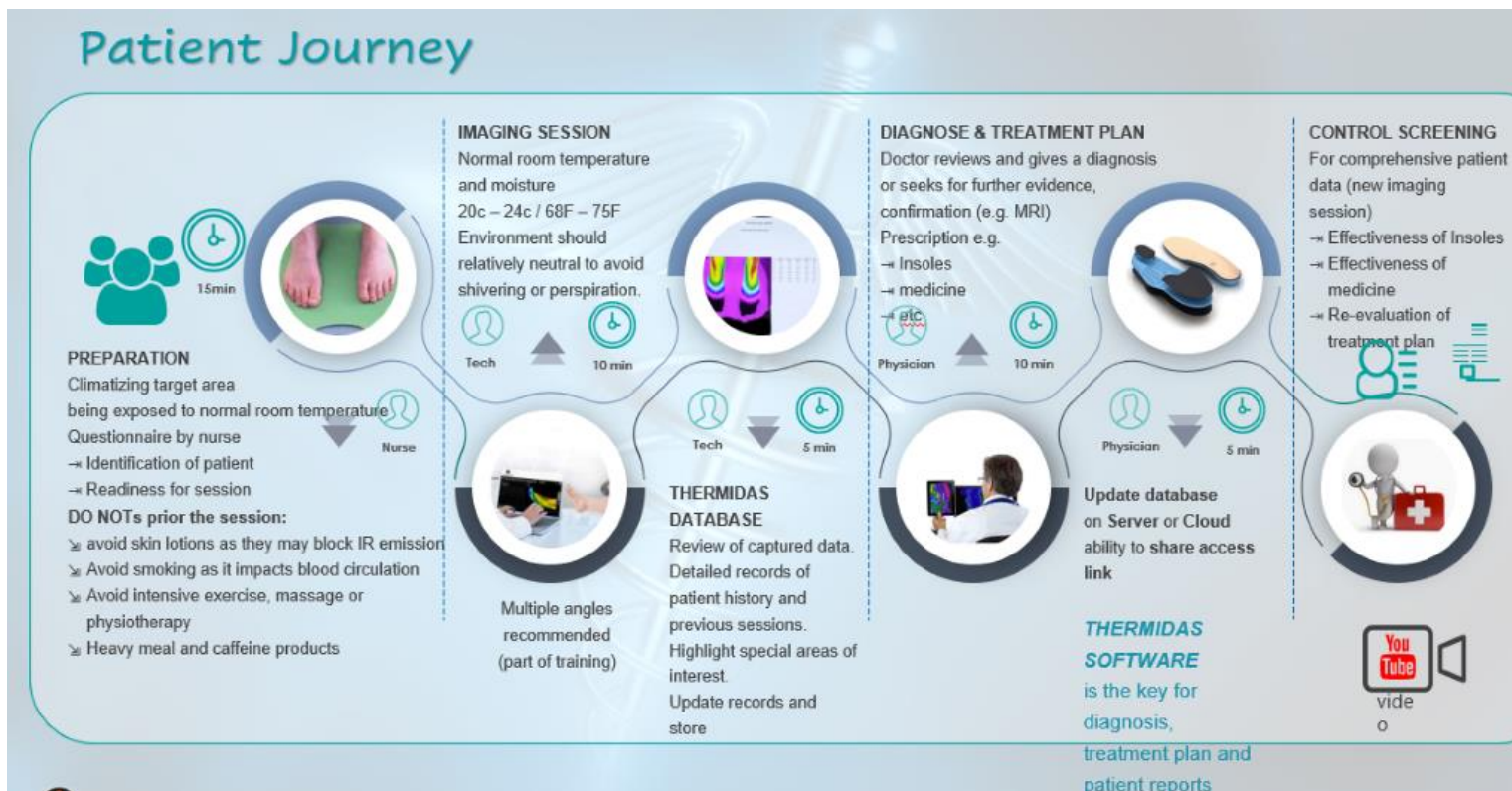
3 RESEARCH PURPOSE

So far ITI has not been part in competence areas for healthcare professionals. Hence so far it has been studied mainly from the outcome or efficiency perspective instead of healthcare professionals' experiences. Good examples of these kind of studies are by

made Petrova (2019, 97-103) and Netten (2013, 1122) which have studied the efficiency of ITI in the treatment of diabetes and discovered that it is possible to detect the diabetic ulcers with ITI.

Normal foot check does not let healthcare professional see under the skin. ITI-system is giving access to compare ITI images to the actual symptoms that the patient is experiencing. One interesting matter is that healthcare professionals will evaluate the body heat in their normal foot check, but it isn't yet marked to current risk rating of diabetes legs. ITI could be one tool in the risk rating in the field of diabetes. In the road of modern recognized imaging ways, this research will show healthcare professional's point of view of novel ITI with diabetic care and the development need in service design regarding ITI. The goal of this research is to provide clear service process for handheld infrared thermal imaging system.

TherMidas company had CE-label for their first ITI-system in 2018 and their first service process has been in use since then and can be seen in picture 1. In addition, service process has not been designed properly for the use of their new handheld ITI-system which got CE-label in 2020. Handheld ITI-system is a combination of camera and computer which allows use of ITI-system in vary environments. Service design areas and target phases in this thesis are for the handheld ITI-system are preparation phase and imaging session phase in picture 3.



Picture 3. Trolley ITI-system service process (TherMidas company materials 2020)

4 SERVICE DESIGN

4.1 Definition of service design

Service design offers a perspective, method, and tool set that enables an organization to realize business ambitions as well as a way to deal with internal and external challenges (Reason, Løvlie & Flu, 2015,12-13). Making new service process for new handheld ITI-system for TherMidas is this kind of challenge.

Service design offers an approach to deal with strategic initiatives as well as operational challenges by asking three fundamental questions: What does new service process for new handheld ITI-system do for TherMidas current and future customers? How will TherMidas company be impacted by having a service process for handheld ITI-system? Which capabilities are needed for TherMidas to respond or to drive the initiative? (Reason et al. 2015,12-13). These questions will guide the researcher way when creating a service process for handheld ITI-system. So far ITI-system has been

mounted to trolley which has limited the use of ITI-system. Handheld ITI-system allows use of ITI-system in a wide range of spaces and environments. TherMidas initiative is to expand the scope of their ITI-system.

When looking at service design as a form of interaction and value co-creation and observe it closely, the role of service beneficiaries is highly relevant. There is no need to be professional designers to be part of this process because this interaction involves actions they have to perform on the basis of their own problem-solving capabilities (Morelli, Götzen & Simeone 2021, 33).

In the case of healthcare service design, the development process must not only address the physical architecture and interior design but also the service journeys, from information finding to the detailed process description, where different touchpoints must be considered. When creating a new service process to hospital environment we have need to trust different experts but to be ready to ideate and test different service solutions in these moments and see how they work in real life (Alhonsuo 2021, 52-60).

The main objective of the service design approach is to resolve customer-related challenges and balance them with business drivers and the organizations' capabilities. Understanding the potential future for TherMidas customers' perspective will provide clarity and direction needed to achieve the best service design result. Seeing a business through TherMidas customers' eyes offers powerful insights that make customers' expectations, experience, and behavior more tangible. It exposes customers' pain points and provides deeper understanding of their emotions. This enables TherMidas to identify clear intervention points that can be leveraged to increase value for their customers and deal with challenges, typically to: Increase customer satisfaction and improve the level of adoption, reduce customer irritation and prevent costly service failures, improve service experience for customers and build better customer relations. Service design can identify exactly which actions will make a real difference to TherMidas customers and helps execute improvements in a way that bring to TherMidas marginal and special customers real and tangible value (Reason et al. 2015,12-13).

Service design also aims to create user-friendly and relevant services, products, facilities and processes. While designing a service focusing on creating a customer's journey, service design addresses what TherMidas must do in order to produce that. (Website of Nielsen Norman Group 2017)

The result of this Thesis will be updated service process for diabetic nurse when using handheld ITI-system. This Thesis is focusing to explore the way in which healthcare professionals experience ITI in part of their daily work routines in the field of diabetic care. Chosen Takeda's service design model consists of five stages: understanding, ideation, selection, test, and implementation stage (picture 4). Takeda's model was chosen because it is easy to attach to my service design goal by having clear five steps to follow through. Takeda's service design model is also well adjustable and tangible for having multiple data-gathering methods in my research.



Picture 4. Existing service design process model in Takeda company (Oleksiuk 2018)

4.2 Phase 1- Understand

Understanding stage: Service design begins with the understanding stage. In order to get insight into healthcare professional's needs, motivations, and wants, the researcher conducts the research (Oleksiuk 2018, 53).

Understanding phase will be formed as qualitative research. This research is made for healthcare professionals, who are the experts in the field of diabetic foot care. TherMidas arrange free TherMidas education and ITI trial to Physiogeriatrics healthcare professionals who are working in Uusimaa region and are involved in diabetic care. The target group are firsthand professionals in the field of diabetic foot care, who could need and benefit from this kind of product. Informative PowerPoint presentations concerning TherMidas is shown to healthcare professionals. Physiogeriatrics healthcare professionals are also educated to use handheld ITI-system

by TherMidas professionals. Physiogeriatrics use handheld ITI-system for a trial period. I contact Physiogeriatrics physiotherapy and rehabilitation services clinic by e-mail after ITI-system trial, and participants are asked to fill a questionnaire (Appendix 1). Questionnaire is created with google forms program. Questions are open ended. The answers are based on healthcare professionals' subjective opinions concerning information that is presented. Based on the answers, question is how healthcare professionals experience the usefulness of the ITI in the diabetic foot care and what kind of service process would be the most useful for healthcare professional in the use of ITI. All collected data are analyzed using the content analysis method and all answers are saved anonymously. Questionnaire answers are disposed after analysis.

IDEATION PHASE	
Research Questions	<ol style="list-style-type: none"> 1. If you are considering the current treatment path for the treatment of a diabetes patient, how do you think a handheld thermal imaging system would develop the current diabetes nurse's chances of supporting a diabetes patient's foot health? 2. If you think about your own work tasks in the treatment path of a diabetes patient in relation to the treatment and prevention of diabetes wounds, what are the challenges of using a handheld thermal imaging device as part of your work? 3. If you think about your own current tasks and a situation where a handheld thermal imaging system is one of your tools, what do you think would be the optimal and realistic nurse's action in treating the wounds of a diabetes patient?
Source	Informative powerpoint presentations and user trial regarding ITI
Methods and data collection	Methodology: Individual interview Data: Semi-structured questionnaire
Analysis	Content Analysis

4.3 Phase 2 - Ideate

Ideation stage: The researcher aims to come up with the best ideas regarding new service process based on results of understanding phase. The researcher scans hospital industry and tries to discover what kind of type of service processes are used in hospitals regarding products which have similarities with ITI and what would be right service process for handheld ITI-system. The researcher scans the markets, especially imaging products and services in order to understand tendencies and possible direction for the development of own solutions before making the first prototype of the first version of the new handheld ITI-system service process (Oleksiuk 2018, 53). Prototyping is the tool which helps to simulate and visualize an idea in order to explain it to members of a team and customers. According to Brown and Katz (2009), the main goal of prototyping is to receive fast and useful feedback and to develop the idea further.

TherMidas is already having service process for their first trolley ITI-system. When creating a new service process for the handheld ITI-system the infrared thermal imaging principles will apply. Based on the analyzed research results from the individual questionnaire and market scan, the first version of new service process is made in cooperation with TherMidas company professionals and with the pioneers, which are already using the ITI products in the hospitals. It is important to set up a workshop with TherMidas professional's and with pioneers from the hospital with Thermidas system to have the most accurate picture of the current service process regarding healthcare professional's working environment. New service process will be created in TherMidas premises by using real life handheld ITI-system and include the results of understanding phase findings for the first service process output.

4.4 Phase 3 - Select

Selection stage: The first prototype is a result of ideation phase made by multidisciplinary team. Multidisciplinary team consists of TherMidas professionals and pioneers from the hospitals which are using ITI in their daily work. Idea is a result of different parties when they have estimated the outcome from the different

perspectives. The multidisciplinary team will select the best idea which also meets business, medical, and usability requirements (Oleksiuk 2018, 53).

Healthcare professionals (nurses and podiatrists) will gather to second meeting for a group interview to see first prototype of new handheld ITI-system service process. To guide the conversation, the frame of a thematic interview will be used. This means that the topics of the group interview are decided beforehand. Group interview theme will be handheld ITI-system service process prototype which was made in ideation stage of this Thesis. Researcher will host the group interview and healthcare professionals give constructive feedback regarding new handheld ITI-system service process model. Researcher guides the conversation and records the meetings data. Recorded material will be transcribed and analyzed with content analysis. The results of this selection stage will be a modified and finalized service process for TherMidas company. All actions and modifications in this stage are based on group interview's analyzed data. (Hirsjärvi, Remes & Sajavaara 2014, 210-212).

SELECTION PHASE	
Research Question	How health care professionals experience the first prototype of new handheld ITI-system service process?
Source	Informative powerpoint presentation regarding new service process
Methods and data collection	Methodology: Thematic group interview Data: Recorded material
Analysis	Content Analysis

4.5 Phase 4 - Test

Test stage: TherMidas company tests the selected idea in order to receive feedback which can be used for the idea improvement. Focus groups and interviews are employed as main tools for testing the new service process idea (Oleksiuk 2018, 53).

Based on the results of complete ITI development research, the opinion of TherMidas company experts and opinions of the hospital units professionals, will produce a service process for handheld ITI-system. TherMidas can test the prototype in their premises with real customers and make their own research how beneficial and useful is the new service process.

4.6 Phase 5 – Implement

Implementation stage: TherMidas company considers the implementation step as the stage which can influence the success of a designed service or product. TherMidas company will receive new service process model from the author and decides how they want to proceed. As a result, to secure an effective introduction of the solution to the market, TherMidas can employ an implementation plan which includes deadlines, responsibilities, and budget of future activities (Oleksiuk 2018, 53). To ensure the planned realization of a service in terms of system, settings, and staff, a guideline can be developed that can serve as an important communication tool between design and execution teams (Moritz 2005, 235).

5 DATA COLLECTION AND ANALYSIS

5.1 Data collection

This study was created as a qualitative study and data was collected with individual questionnaire and thematic group interview made with focused healthcare professionals. New service process is based on analyzed research results and opinions

of TherMidas company professionals. This study took place in a physiotherapy and rehabilitation services clinic Physiogeriatría which provides treatment and counseling to people with diabetes in the Uusimaa region in Finland.

Physiogeriatría provide's comprehensive physiotherapy and rehabilitation services for working-aged people, the elderly, people with memory disorders and veterans at 11 service points, care homes and customers' homes. Physiogeriatría is a rehabilitation partner for more than 110 organizations in the health and social services sector. In multi-professional cooperation, Physiogeriatría build's suitable rehabilitation solutions and operating models for different organizations and is involved in the change processes required for the future. At the same time, they train work communities and professionals as experts in the rehabilitation of older people. Physiogeriatría healthcare professionals works to prevent diabetes and its complications and to improve diabetes care. Healthcare professionals also give lectures regarding diabetes. If necessary, healthcare professional sends the client for further treatment, for example, to a doctor or physiotherapist (Physiogeriatría webpage 2022).

How many participants are "enough" can depend on many factors, but as long as you have sufficient interview data, whether from one person or twenty, you'll then have a sufficient corpus for analysis. Interviews are the most common form of data gathering in qualitative research studies, because they directly will give the perspectives of the people we wish to study. Multiple data-gathering methods enhance the credibility and trustworthiness of a study through what is known in the field. Multiple data gathering methods are purposefully chosen for several reasons. First, data gathered from different sources will better guarantee a spectrum of diverse perspectives for analysis and representation (Saldana, Leavy & Beretvas 2011,34-76). This survey research involves two data gathering methods.

Survey research generally studies large samples in order to generalize across many cases, and/or to provide enough cases to employ comparative analysis to control variables. By contrast, qualitative inquiry often involves investigation of a small number of naturally occurring cases, perhaps just one or two (Hammersley 2013, 11).

An interview should be theme centered, interpersonal, based on an assumption of shared meaning, qualitative in nature, descriptive, particular in intent, presumption less, supported by minimal ambiguity, able to be altered, sensitive to each person, focused on a phenomenon, and a positive experience for all people (Barnard, McCosker, & Gerber 1999, 222).

5.2 Data analysis

Content analysis is the systematic examination of texts and visuals (e.g., newspapers, magazines, speech transcripts), media (e.g., films, television episodes, Internet sites), and/or material culture (e.g., artifacts, commercial products) to analyze their prominent manifest and latent meanings (Saldana et al. 2011, 10).

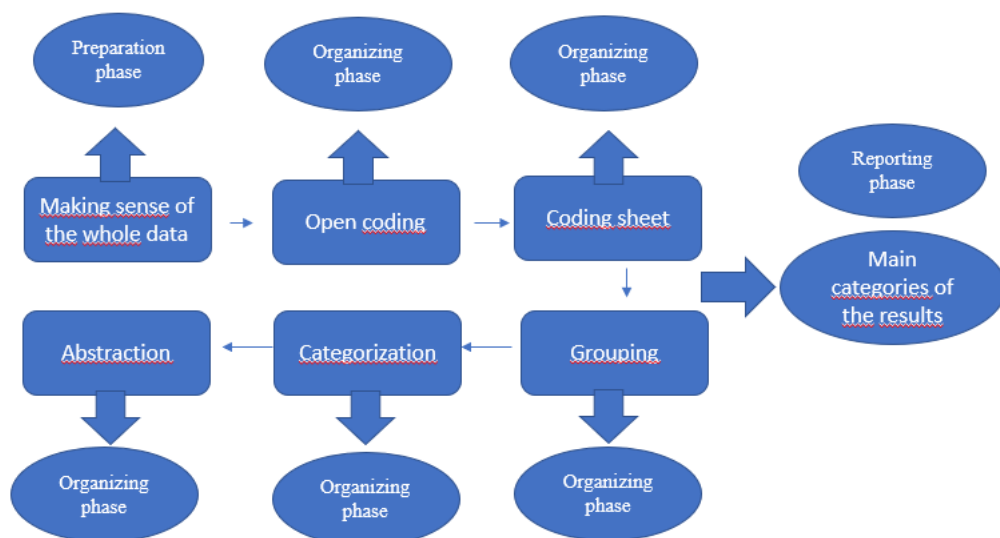
Content analysis could either be deductive or inductive. Inductive content analysis is used in cases where there are no previous studies dealing with the subject or when it is fragmented. A deductive approach is useful if the general aim was to test a previous theory in a different situation or to compare categories at different time periods. The key feature of all content analysis is that the many words of the text are classified into much smaller content categories (Elo & Kyngäs 2008, 108-109). Both data collection methods, individual questionnaire and thematic group interview were analyzed via inductive content analysis (picture 5) in this research.

Trustworthy content analysis is versatile, and the data is well-saturated. Trustworthy content analysis includes trustworthiness of the data collection method, sampling strategy, and the selection of a suitable unit of analysis. Together, these phases should give a reader a clear indication of the overall trustworthiness of the study (Elo, Kääriäinen, Kanste, Pölkki, Utriainen & Kyngäs, 2014, 3).

The key feature of all content analysis is that big content of the text is classified into much smaller content categories. There are three main phases to follow: Preparation phase, organizing phase and reporting phase. The preparation phase starts with selecting the unit of analysis which can be a word or a theme. Depending on a research question, the unit of analysis can also be a letter, sentence, portion or pages or words,

the number of participants in discussion or the time used for a discussion. Next in the analytic process, the researcher strives to make sense of the data. The written material is read through several times and researcher will become completely familiar with the data. After well-conducted preparation phase next is to organize the qualitative data. This process includes open coding, creating categories and abstraction. Open coding means that the notes and headings are written in the text while reading it. The written material is read through again, and as many headings as necessary are written down in the margins to describe all aspects of the content. The headings are collected from the margins on the coding sheet and categories are freely generated at this stage. After open coding the list of categories are grouped under higher order headings. The aim is to reduce the number of categories and find the most important ones and remove those that are similar or dissimilar into broader higher order categories. (Elo & Kyngäs 2008, 109).

The research had two set of data collection events for the healthcare professionals, which were individual questionnaire interview and thematic group interview. The answers of individual questionnaire were collected with google forms program and analyzed using inductive content analysis process (Picture 5). Thematic group interview was sound recorded and analyzed using inductive content analysis process.

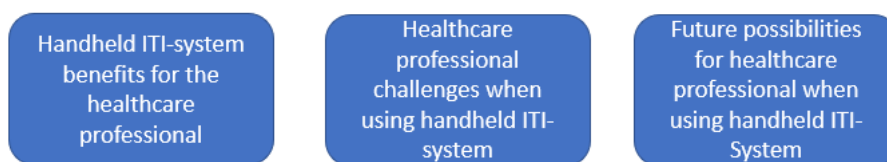


Picture 5. Inductive content analysis process based to the content analysis process of Elo and Kyngäs (2008, 110).

The data from the individual questionnaire and group interview were opened in a coding sheet. When results had analyzed it was clear how much further handheld ITI-system service process is possible to develop. Healthcare professionals were informed that participation of this research was voluntary, and no personal data were recorded.

Abstraction means formulating a general description of the research topic through generating categories. The purpose of creating categories is to provide a means of a describing the phenomenon, to increase understanding and to generate knowledge. Each category is named using content-characteristic words. Subcategories with similar events and incidents are grouped together as a categories and categories are grouped as main categories. (Elo & Kyngäs 2008, 109).

The researcher browsed the data multiple times and gathered the replies of the individual questionnaire (Table 2). Researcher made abstraction for the findings to find the significant messages from the text and regarding healthcare professionals' opinions of handheld ITI-system. As main categories, researcher created three key question areas (picture 6) based to the individual questionnaire interview made for the healthcare professionals. After creating key question areas researcher made three generic categories based of the similar opinions that arise from the material. After the material was placed to generic categories, the researcher tried to find the final findings of individual questionnaire interview and then placed the findings under sub-categories to see the results more efficiently.



Picture 6. Key question areas according to the research questions of this research

6 SERVICE PROCESS FOR DIABETIC NURSE WHEN USING HANDHELD INFRARED THERMAL IMAGING SYSTEM

6.1 Phase 1- Individual data collection setting

Individual questionnaire interviews as a research method, gives interviewee chance to participate in the process of data collection, through face-to-face interview, via telephone or via internet link. The process of interviews requires the research author asking questions for data collection and the respondent answering them (Kohtari 2004, 99).

First data gathering method in this research was individual questionnaire. This interview was semi-structured and had open questions, which gave greater flexibility to process. Two healthcare professionals participated to this research. To have better view of the small portion of results, the researcher decided to show all answers. Answers were manually translated into English by the researcher. To have a better view of the data and the findings from individual questionnaire, answers were listed in table 2. After listing answers researcher made abstraction process (Figure 1-3).

Table 2. Healthcare professionals replies to three key question areas

Main categories	Research results
Handheld ITI-system benefits for the healthcare professional	<ul style="list-style-type: none"> • Include ITI as part of the treatment chain in the same way as monofilament research • In the private sector in particular, thermal imaging could work in monitoring the effectiveness of the rehabilitation of inflammatory and could be offered as an additional service • During examinations of the diabetic's feet, it would be beneficial to ITI scan the feet regularly in connection with other studies (e.g. monofilament test, vibration sensation, ABI measurement). This could prevent possible wounds if feet lightening treatments could be started even before the wound was born. • In identifying Charcot's leg, ITI could play a big preventive role.
Healthcare professional challenges when using handheld ITI-system	<ul style="list-style-type: none"> • Foot temperature stabilization takes 15 minutes from total reception time what is usually around 60 minutes totally. It makes sense to do imaging before before hardening removal, because often some indication of ITI arises from the customer's speech only during treatment. There is less time left for imaging after other treatment has started. • ITI-Systems are expensive, not everyone has access to them. • Standardized imaging, and in particular the reading of ITI images and the conclusions drawn from the pictures, can be challenging and vary between different healthcare professionals; what should be interpreted from the images and how to act on them? • ITI needs to be done for a long time in order to form a routine that also gives confidence to healthcare professional in imaging or, in particular, in reading ITI images.
Future possibilities for healthcare professional when using handheld ITI-System	<ul style="list-style-type: none"> • Recommendation for additional ITI service for each patient. Musculoskeletal disorder clients as part of the initial assessment and as a measure of the effectiveness of rehabilitation. • Regular imaging depending on the risk category (e.g. 1-2 times per a year in patients with risk category 0-1). • Writing statements, for any other health care providers and patient records. If there were changes or risk factors in the images, the patient's monitoring and treatment could be increased or sent for further treatment to another party if necessary. • ITI could be used to monitor the healing more frequently and at the same time not to forget to monitor other areas so that wounds cannot be created elsewhere.

6.1.1 Handheld ITI-system benefits for the healthcare professional

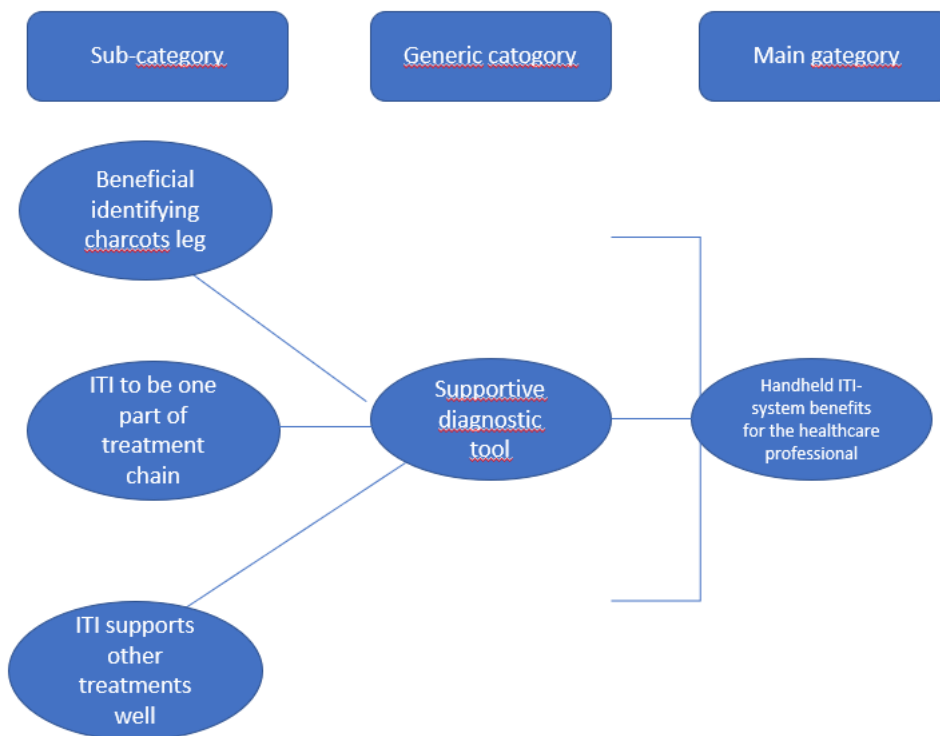


Figure 1. Benefits of ITI after abstraction process based to Elo and Kyngäs (2008, 110).

Healthcare professionals experienced that ITI could be one part of treatment chain and ITI would be beneficial tool especially identifying Charcot's leg. Healthcare professional experienced also that ITI supports other treatments well.

6.1.2 Healthcare professional challenges when using handheld ITI-system

During ITI-system trial period, healthcare professionals experienced that foot temperature measurement time consumption too big part from patient visit. Healthcare professionals felt ITI-system can be too expensive investment. Standardized imaging and conclusions of the images between healthcare professionals can also vary too much. Healthcare professionals experienced ITI takes time to learn to use ITI such way it will be beneficial for the user and for the patient and to form to be a routine among other treatments.

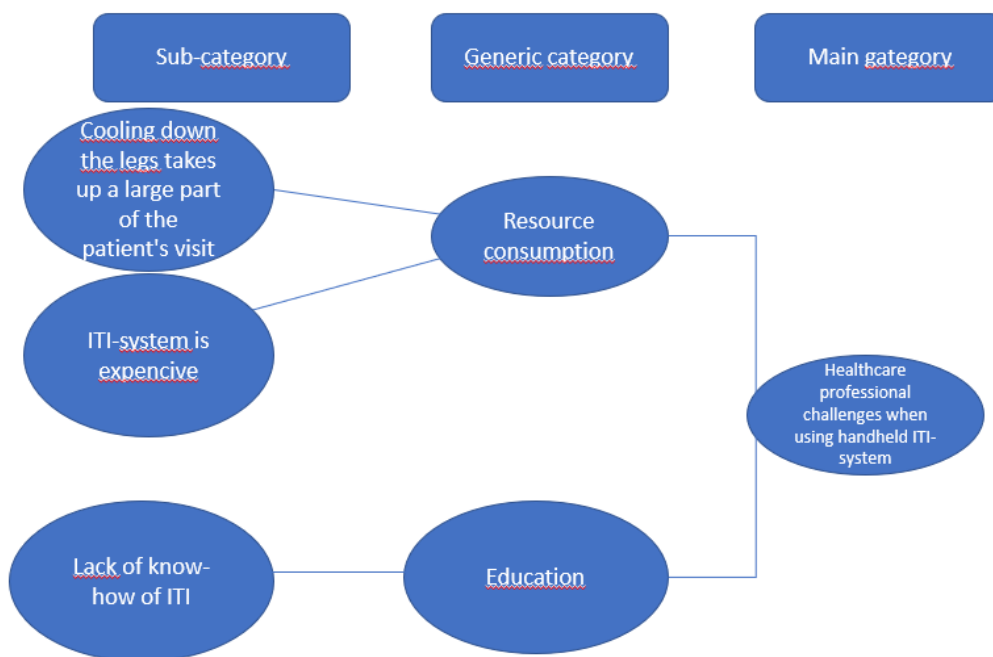


Figure 2. Challenges experienced regarding ITI after abstraction process based to Elo and Kyngäs (2008, 110).

6.1.3 Future possibilities for healthcare professional when using handheld ITI-System

Healthcare professionals experienced that ITI could be sell out as an extra service. ITI was seen with musculoskeletal disorder clients as part of the initial assessment. ITI could be a part of diabetic patient treatment path. ITI was seen as a good tool to follow up patient wounds and same time monitor other areas so that wounds cannot be created elsewhere.

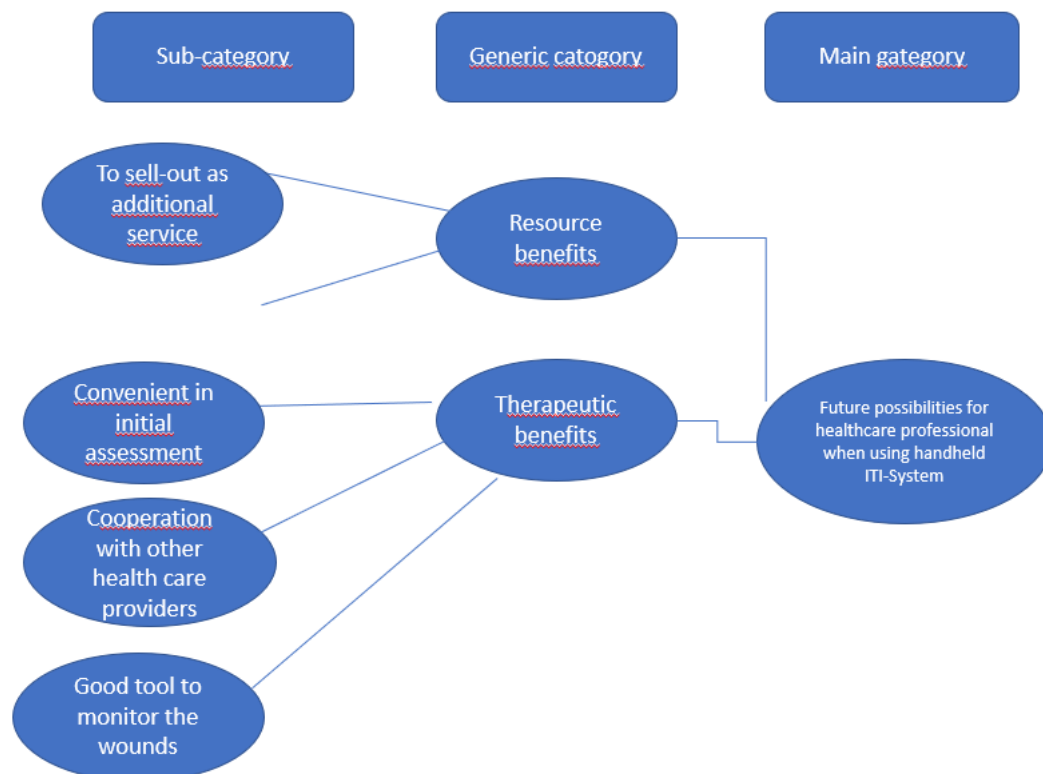


Figure 3. Future possibilities of ITI after Abstraction process based to Elo and Kyngäs (2008, 110).

6.2 Phase 2- Service process ideation with TherMidas and market scan

The researcher scanned the markets, especially imaging products and services available in the hospitals to have ideas to develop handheld ITI-system service process further from trolley ITI-system and to discover the benefits of new handheld ITI-system. When a new service process for the handheld ITI-system was created, the ITI principles had to apply to new handheld ITI-system service process. The researcher wanted to know would there be similar products or service processes which already worked or not when imaging services was used.

Next sub-headers focus to present the researcher findings made in research phase two to understand the imaging service industry. Researcher will present the negative features (Table 3) given by each imaging service processes. These finding was compared to existent trolley ITI-system service process (figure 4) findings when creating handheld ITI-system service process. By doing so and in building new service

process for handheld ITI-system, the researcher tried to add or avoid adding other negative imaging service process features to handheld service process to build the most effective service process for handheld ITI-system.

6.2.1 MRI

Magnetic resonance imaging (MRI) scan (Picture 7) is an established imaging method and the procedure is based on the water in the magnetic field, in the radio waves and in humans. An MRI scan is used for examining musculoskeletal disorders and accidents, the head and neck area, the stomach area, the breasts, cardiovascular diseases. Precise images of the part of the body under examination will be taken in two or three perpendicular directions opposite each other. The examination uses devices, that contain coils capable of receiving radio waves, which are placed around the area of the body being studied. A radiology specialist will give a written statement about the examination based on the preliminary information given by the doctor who directed the patient to the scan, results of the MRI scan and possible old images, which can be compared to the new ones. The images from the scan as well as the statements can also be seen at the latest 3 to 14 days after the examination (Mehiläinen webpage 2022).



Picture 7. MRI scan (Mehiläinen webpage 2022)

The presence of a strong magnetic field means the metal objects of any kind are not permitted within the scanning room during an MRI Scan. All jewelry and clothing containing metal, particularly objects containing iron, need to be removed. If a patient suspects they may be pregnant, the doctor must be informed, as little is known about the effect of MRI scans on an unborn baby. Once you are dressed in a medical gown, you will be asked to lie down on a narrow table which will then move into the tunnel. An MRI can last from 30 minutes to an hour, depending on the scans being performed. An MRI is a very expensive and time-consuming investigation compared to other imaging methods (Virtual medical centre webpage 2022).

In an MRI scan healthcare professional asks the patient lays down in the position they need to be imaged in and asks patient to stay completely still. The machine can make strong sounds during the examination. To protect the patient's hearing, healthcare professional give headphones to patient with the ability to listen to music are provided. (Mehiläinen webpage 2022).

6.2.2 External ultrasound

An ultrasound scan (picture 8) uses high-frequency sound waves to create images of the inside of the body. It is suitable for use during pregnancy. The person who performs an ultrasound scan is called a sonographer, but the images are interpreted by radiologists, cardiologists, or other specialists. The sonographer usually holds a transducer, a hand-held device, like a wand, which is placed on the patient's skin. Ultrasound is sound that travels through soft tissue and fluids, but it bounces back, or echoes, off denser surfaces. This is how it creates an image. The sonographer puts a lubricating gel onto the patient's skin and places a transducer over the lubricated skin. The transducer is moved over the part of the body that needs to be examined. Ultrasound scans, or sonography, are safe because they use sound waves or echoes to make an image, instead of radiation. No special preparation is normally necessary before an ultrasound scan. The patient should not feel discomfort or pain. During pregnancy, an ultrasound may be slight discomfort for the patient. They will just feel the transducer over the skin (Wilson 2017,15).



Picture 8. External ultrasound scan (Wilson 2017)

6.2.3 X-ray

An X-ray (Picture 9) examination is a traditional imaging method using X-rays, which is used in the examination of a variety of diseases and traumas to the locomotor system, respiratory system and cardiovascular system. X-rays are usually carried out in hospital X-ray departments by trained specialists called radiographers, although they can also be done by other healthcare professionals, such as dentists. Nowadays, X-ray examinations are less often used for examinations of the abdominal area and the urinary tract. For the spine and some joints, images will often even be taken from several directions. The imaging will be carefully limited to the area to be examined. It is important not to move during the imaging. Common reasons for having an X-ray are respiratory inflammations, such as suspected sinusitis or pneumonia, the evaluation of the degree of cardiac insufficiency as well as any degenerative, inflammatory or accident damage to bones and joints. Based on preliminary information provided by the referring doctor in his/her examination request, the imaging results and any possible comparisons that can be made with previous images, the radiologist will provide a written report on the examination (Mehiläinen webpage 2022).

Patient don't usually need to do anything special to prepare for an X-ray. Patient can eat and drink as normal beforehand and can continue taking your usual medications. Patient may need to stop taking certain medications and avoid eating and drinking for a few hours if you're having an X-ray that uses a contrast agent. For all X-rays, patient should let the hospital know if pregnant. X-rays aren't usually recommended if you're pregnant unless it's an emergency. During an X-ray, patient usually will be asked to lie on a table or stand against a flat surface so that the part of your body being examined can be positioned in the right place. The X-ray machine, which looks like a tube containing a large light bulb, will be carefully aimed at the part of the body being examined by the radiographer. The radiographer will operate the machine from behind a screen or from the next room. The X-ray will last for a fraction of a second. Patient won't feel anything while it's carried out. More than one X-ray may be taken from different angles to provide as much information as possible. The procedure will usually take a few minutes. The X-ray images will often need to be examined by a radiologist before you're told the results. A radiologist may discuss their findings with patient on the same day, or they may send a report (NHS Webpage 2022).



Picture 9. X-ray scan (Medical device-network webpage 2022)

6.2.4 Computerised Tomography

Computerized tomography (CT) is an X-ray examination, which provides cross-sectional images of the body. This examination is quick and easy and during it the patient lies on the examination table, which passes through a ring-like imaging machine (Mehiläinen webpage 2022).

CT scans (Picture 10) can produce detailed images of many structures inside the body, including the internal organs, blood vessels and bones. CT scans are carried out in hospitals by specially trained operators called radiographers. Patient will receive appointment letter where patient is informed patient to prepare for the scan. Patient may be advised to avoid eating anything for several hours before appointment to help make sure clear images are taken. Patient should contact the hospital after receiving appointment letter if patient have any allergies or kidney problems, or if patient taking medication for diabetes, as special arrangements may need to be made. Patient should also let the hospital know about pregnancy. CT scans aren't usually recommended for pregnant women unless it's an emergency, as there's a small chance the X-rays could harm baby. Patient is advised to wear loose, comfortable clothes as patient may be able to wear these during the scan. Patient should avoid wearing jewelry and clothes containing metal (such as zips), as these will need to be removed. Before having the scan, patient may be given a special dye called a contrast to help improve the quality of the images. This may be swallowed in the form of a drink, passed into patient bottom (enema), or injected into a blood vessel. Patient can inform the radiographer feeling anxious or claustrophobic about having the scan. Radiographer can arrange for patient to have a sedative (medication to help you relax) if necessary (NHS Webpage 2022).



Picture 10. CT scan. (NHS Webpage 2022)

6.2.5 Mammography

Mammography (Picture 11) is a traditional imaging method using X-ray radiation, which is used for investigating the diseases of the mammary glands. In most cases, an ultrasound examination of the breasts is added to a mammogram as these two investigative methods complement each other. Some changes are most reliably detected using a mammogram, whilst others are most obvious in an ultrasound scan.

During an X-ray examination, the radiographer in general takes mammogram images from two different directions. If required, targeted or magnified images can be taken in order to evaluate minor changes. During the imaging, inside the imaging device, the breast to be examined will be pressed evenly between a plastic plate and the imaging cassette so as to improve picture quality and to minimize the radiation stress caused by the imaging. A mammogram and a breast ultrasound scan usually take a maximum of 30 minutes. Based on preliminary information provided by the referring doctor in his/her examination request, the imaging results and any possible comparisons that can be made with previous images, the radiologist will provide a written report on the examination (Mehiläinen webpage 2022).



Picture 11. Mammograph scan device (Bulevardclinic webpage 2022)

6.2.6 TherMidas trolley ITI-system

TherMidas ITI System is intended for use by trained healthcare professionals in care facility. It is non-invasive skin temperature imaging software for image analytics that measures temperature with a separate infrared thermal camera. Infrared imaging is safe for the patient because it does not emit rays it only receives them. The method of measurement is based on the conduction of heat in a known material. The thermal camera measures thermal radiation, i.e., the so-called surface temperature of the area under study. ITI devices have many uses such in diabetic foot, suspected skin neoplasms, skin grafts, arthritis, and pressure injuries. Application areas in diabetic foot cover e.g., diabetic foot ulcers and skin microcirculation. ITI images can be taken

by a trained person. The camera that detects thermal radiation and takes thermal images does not touch the patient, does not cause pain to the patient, and the study does not require invasive examinations (Sippola, 2021, 10-15). TherMidas had their own ITI imaging training course which they offered to their customers.

TherMidas had service process for their first trolley ITI-system which was already used by healthcare professionals (Picture 3). Based on the analyzed research results in phase one and the market scan made in phase two, the first version of new service process was made in cooperation with TherMidas company professionals and with the pioneers, which already used the ITI products in the hospitals.

TherMidas trolley ITI-system (Picture 12) is an IR thermal imaging system that offers a novel imaging method for early diagnostics and treatment follow-up in select areas of therapy. The product is comprised of an IR camera, a PC, a mobile workstation, and software for image analytics. At the core of the product is an easy-to-use thermal imaging application developed by the company (Thermidas webpage 2020).



Picture 12. TherMidas trolley ITI-system ((Thermidas webpage 2020)

Trolley ITI-system served as a good example of the direction in which development work should be taken. In the beginning of the development process the main service design areas and target phases in this thesis for the handheld ITI-system were preparation phase, imaging session phase (figure 4).

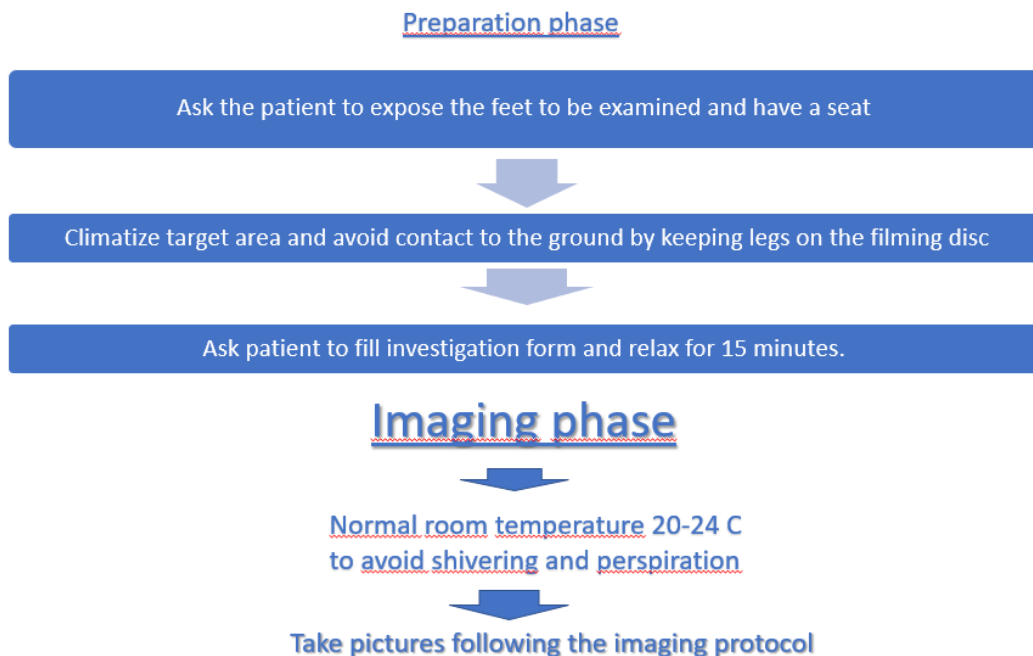


Figure 4. Trolley ITI-system preparation phase and imaging phase in a nutshell (TherMidas Webpage 2022)

6.2.7 Market scan results

Table 3 presents the negative features given by each imaging service processes when imaging services were compared to each other. Resource consumption includes imaging service time consumption when imaging service is used. Medical harm for the patient includes how much the patient is exposed to radiation during imaging service. Psychological stress for the patient includes is the procedure unpleasant for the patient. Medical harm for the professional includes is healthcare professional exposed to radiation during imaging service.

Table 3. Negative features given by each imaging service processes

Imaging service	MRI	External ultrasound	X-ray	Computerised Tomography	Mammography	ITI
Resource consumption	X				X	
Medical harm for the patient	X		X	X	X	
Psychological stress for the patient	X		X	X	X	
Medical harm for the professional			X	X		

There were four strong benefits (Figure 5) when using trolley ITI-system comparing to other imaging services. These four became even stronger when creating the new service process prototype for movable handheld ITI-system.

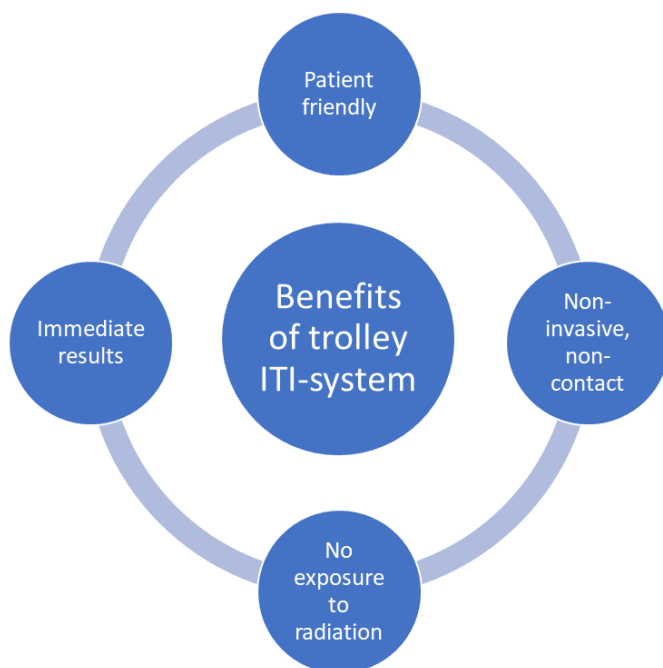


Figure 5. Trolley ITI-system benefits comparing to other imaging services

6.2.8 The new service process prototype for handheld ITI-system

Service process prototype for handheld ITI-system was based to three main parts in this research:

- Markets scan regarding different imaging services and service processes
- Subjective experiences of target healthcare professionals regarding ITI informative materials and to their experience of handheld ITI-systems
- TherMidas multidisciplinary team opinions about new handheld ITI-system service process prototype

Market scan results in phase 2 (table 3) showed that handheld ITI-system resource consumption is low comparing to other imaging services. Market scan also showed that external ultrasound had the most compatible imaging service process to look at when handheld ITI-system service process was created. It came clear that ITI is very compatible in many ways comparing to other imaging services. This gave author flexibility for creation process when new handheld ITI-system service process was designed.

Individual questionnaire interview in phase 1 gave a result that the resource consumption was too big when handheld ITI-system was used. Healthcare professionals experienced that foot temperature measurement time consumption was too big part from patient visit (figure 2). Target imaging area need to be exposed to normal room temperature for 15 minutes before imaging and patient needs to avoid expose target area to any surfaces or strain target area. Author needs to mention that healthcare professionals haven't use trolley ITI-system and they only had user experience concerning handheld ITI-system. Handheld ITI-system itself release resource consumption comparing to trolley ITI-system because it can be used more flexible and faster way. This was the fifth strong benefit related to trolley ITI-system and when different imaging services were compared (figure 5).

Based to the results, the author decided to focus for these two findings when creating the service process prototype for the handheld ITI-system. Healthcare professionals

felt that couldn't use ITI beneficial way because of lack of experience and knowledge about ITI (figure 2). Healthcare professionals needed more education to use ITI among other treatments.

Ideation meeting was held in spring 2022 at with TherMidas company premises with TherMidas multidisciplinary team. The author presented the results made in the phase 1 and the first version of the service process prototype made by the author (picture 13) to TherMidas multidisciplinary team. Researcher ideas which were based to phase 1 are high lined with green color.



Picture 13. Handheld ITI-system service process prototype vol 1 before ideation meeting

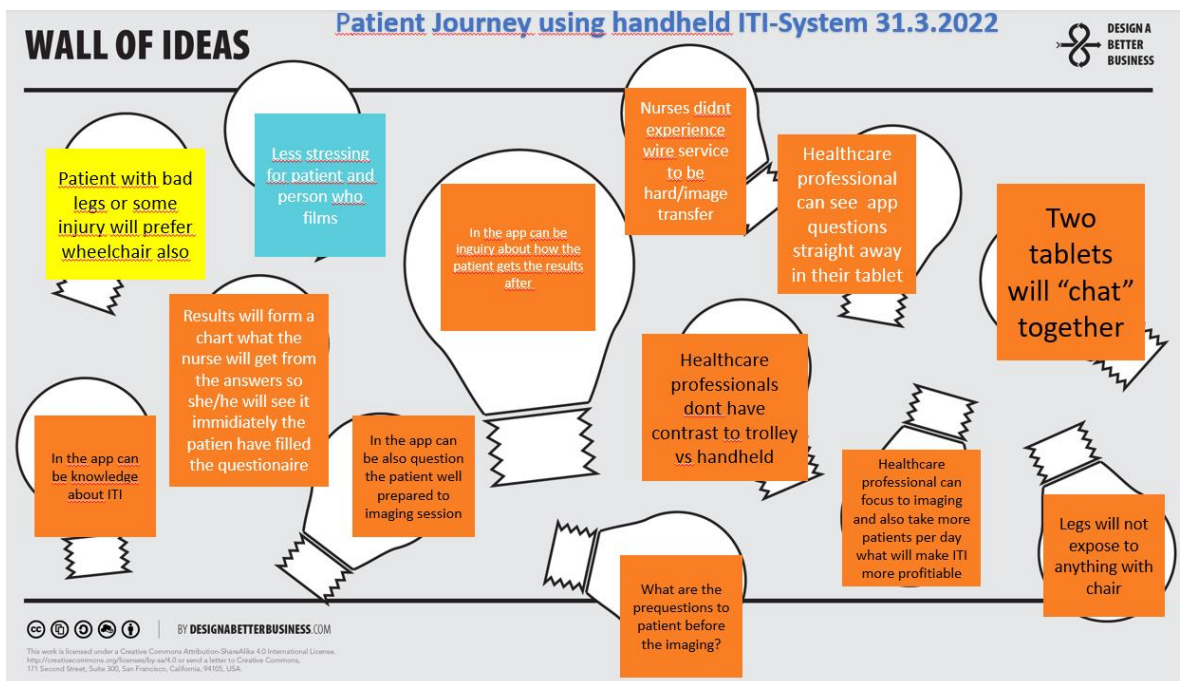
TherMidas multidisciplinary team was impressed of the first version of the prototype and gave good feedback regarding the two new feature innovations made by the author. Based to the results in phase 1 the author focused to develop service process which would save healthcare professional time but also follows the ITI imaging protocol. The author developed two new features to preparation phase.

TherMidas imaging chair. To follow the ITI imaging protocol the patient needs to expose the target area to normal room temperature for 15 min before the imaging. TherMidas imaging chair with wheels and leg stand will reduce the time what healthcare professional needs with each patient but the imaging procedure will still follow the imaging protocol. Wheels allow patient to move without exposing target area to any surfaces. The author wants to mention that Physiogeriatrics physiotherapy and rehabilitation services clinic patients are elderly people and most of them already move with a wheelchair.

TherMidas questionnaire app. TherMidas questionnaire app will reduce the time even more because the patient can fill the pre-questionnaire with tablet computer while waiting TherMidas imaging chair. Healthcare professional will see pre-questionnaire results after the patient have filled the pre-questionnaire form and can focus on the patient imaging. This will reduce imaging errors because healthcare professional can focus only for the imaging and to the patient.

Imaging situation can be stressing for the patient. It can be good for the patient to focus fill a pre-questionnaire. The patient will have time also to browse information about ITI before imaging situation from the app. TherMidas questionnaire app also reduce the time patient needs to be in the clinic. TherMidas questionnaire app can be modified easily. TherMidas questionnaire app can be modified to customer and healthcare professional need by adding new features to the app based to the user experiences.

TherMidas multidisciplinary team and the author focused to develop new features even further and second version of the handheld ITI-system service process was created. Results of the ideation meeting are seen in wall of ideas canvas (picture 14). The ideation team focused to gather different ideas to the wall. After ideation the team started to build the next version of the prototype (picture 15).



Picture 14. Wall of ideas with TherMidas multidisciplinary team (designabetterbusiness webpage 2022)

The development team made changes to patient journey when handheld ITI-system is used. Patient journey was based to trolley ITI-system service process. The authors own ideas were headlined with green color and changes made in with TherMidas multidisciplinary team were headlined with red color (picture 15).

The development team made changes to handheld ITI-system service process prototype made by the author by adding data transfer phase and image analyze phase to new service process.



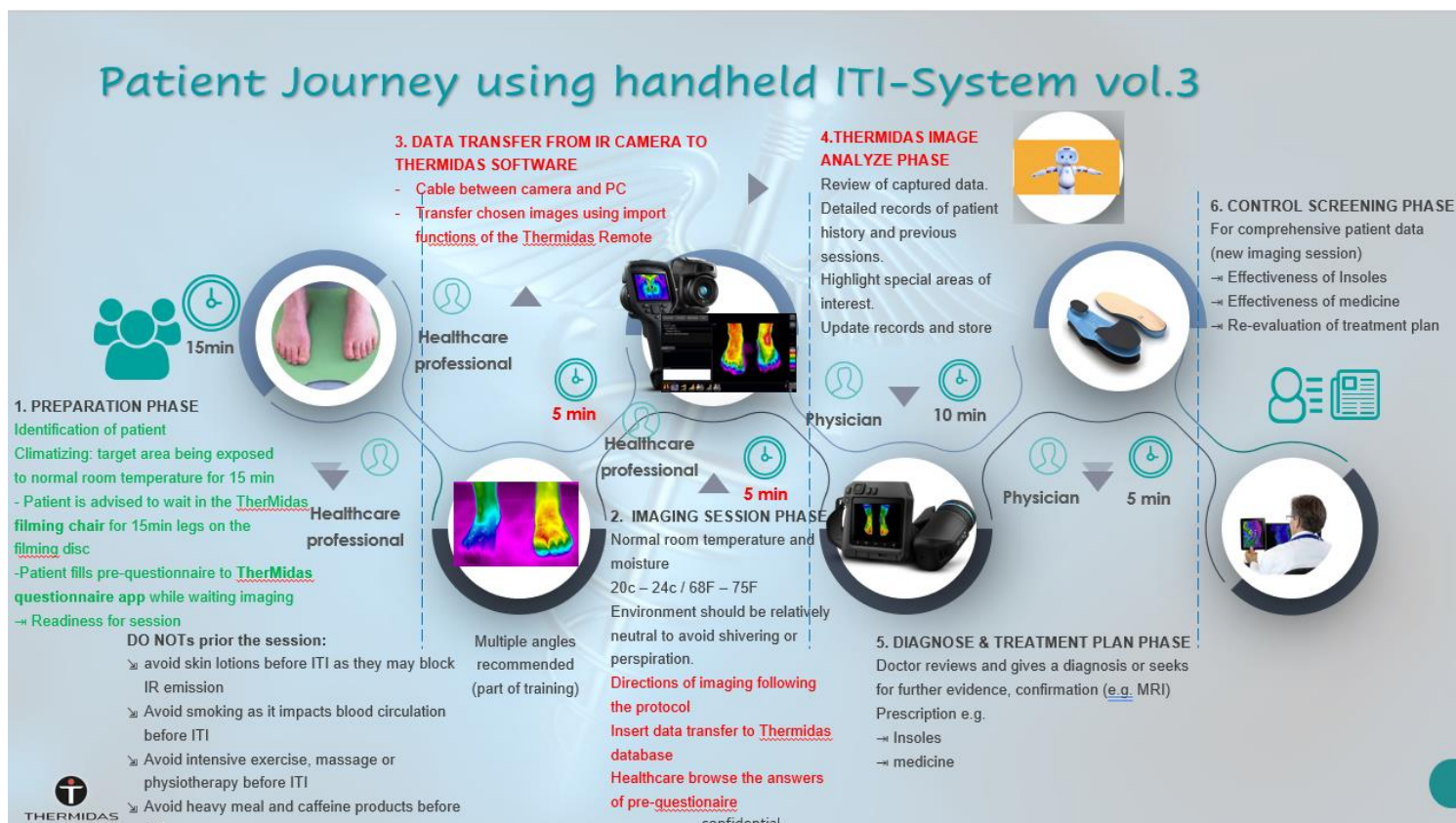
Picture 15. Handheld ITI-system service process prototype vol2 after ideation meeting

TherMidas artificial intelligence bot. After the ideation meeting there was still one resource consumption factor which author needed to tackle. What could be solution to make healthcare professionals to feel more secure when they use handheld ITI-system among other treatments? Author had an idea that healthcare professionals could learn to use ITI through their work and the author invented an artificial intelligence bot (picture 16) which would assist the healthcare professionals when ITI was being used. TherMidas multidisciplinary team has got tools and people to make this kind of bot. Bot would not straight answer to healthcare professional's questions, but it would help by showing example pictures from the real cases of different symptoms. This way healthcare professionals would learn through work and TherMidas would get valuable data from each healthcare professional to develop their bot even further. Bot answers would be based to literature, research data and to patient data. This way the artificial intelligence bot could also develop itself and to be even more reliable and accurate in the future.



Picture 16. TherMidas artificial intelligence bot example

The author made the changes to handheld ITI-system service process prototype (picture 17) what was presented for healthcare professional in thematic group interview in phase 3.



Picture 17. Handheld ITI-system service process vol 3 after developments

6.3 Phase 3 - Thematic group interview data collection setting

Second data gathering method in this research was thematic group interview. Healthcare professionals were invited to the thematic group interview by sending invitation via e-mail. Group interview was held as an online meeting using Teams-program. All two participants joined to the meeting. Group interview theme was new handheld ITI-system service process prototype which was made in understanding phase and ideation phase of this Thesis. The author presented analyzed findings to participants using PowerPoint-program. PowerPoint-program is a good tool to be able to show the whole development process and to clarify the research results. Participants interacted and thematic group interview was sound recorded. The role of the researcher in the group interview was to guide the conversation. Topic questions were decided beforehand by the author to have best opinions arise regarding new service process benefits, challenges, and future possibilities (Table 4). The researcher asked questions from everyone in the group and made specify questions during interview to participants. Interview lasted 34 minutes and the conversation was easy and inspiring during the whole interview. Researcher listened the data multiple times and gathered the answers of the group interview to show all answers for the reader (Table 4).

Table 4. Key results of the group interview

Group interview question	Research results
1. What was the best experience regarding ITI?	<ul style="list-style-type: none"> • Accessibility is the best factor with ITI • The app and chair sound good because waiting time is often wasted • May show the patient what their thermal images look <u>like</u> and the patient could like this too
2. Where would you see this ITI-system to be used?	<ul style="list-style-type: none"> • Diabetics patients • Monitoring the effectiveness of insoles, because if there are symptoms of insoles, you can see if the results have been achieved and verified by thermal imaging. • To monitor pressure wounds in elderly care homes
3. When you look at new service process, is there something you would change?	<ul style="list-style-type: none"> • The practice would dictate how the process would take shape with time as nurses work in practice with patients. • The operation of the waiting room should be carefully considered and how useful the operation with the tablet would be for the nurse. Perhaps the biggest question is whether the exposure of the feet to anything can be ensured when the patient is in a different room than the nurse • There could also be problems with space solutions, as the treatment facilities are often small and there may not be a real waiting area where, for example, a chair can fit. A wheelchair-shaped chair could be a good one to move with older customers • All technological solutions that will be used should be easy to use, older people are sometimes a bit anti-technology.
4. What is good in new service process?	<ul style="list-style-type: none"> • There were very good ideas, and as it sounds, these changes might <u>actually make</u> that schedule easier • It is important to shorten the time, especially in cooling phase • The app was also good solution and would certainly reduce time and more people can be treated per day
5. Would you need a guiding wizard beside to your work to help you when ITI is being used?	<ul style="list-style-type: none"> • It may limit flexibility if the wizard doesn't fit, so it should be carefully thought out. • In the early stages and with new nurses, it would be good, so to speak, to learn how to use the device through the wizard and through memory rules.
6. Which camera would be more suitable for this service process?	<ul style="list-style-type: none"> • FLIR T560 Professional Thermal Camera was better because it made it easier and gave feeling that the camera wouldn't fall off. • FLIR E96 <u>Professional</u> Thermal Camera was a little more challenging for the nurse and didn't have a swivel optics that made it difficult to find the right angle. • The pistol model was lighter, but it didn't <u>had</u> swivel optics and the shooting position was sometimes difficult to manage
7. Do you see your answers taking considered in this service process prototype	<ul style="list-style-type: none"> • Yes, nurses can see the effects of their own opinions in the ITI-system new service process
8. What kind of support would need to do imaging successfully	<ul style="list-style-type: none"> • operating support phone would be good if there is an acute situation

Researcher made abstraction process again like in phase 1 for the key results of the group interview to find the significant messages from the sound recorded research material. Researcher created three key question areas (picture 18) like in phase 1 based to the group interview made for the healthcare professionals. After creating key question areas researcher made three generic categories based of the similar opinions

that arise from the material. After the material was placed again to generic categories, researcher made abstraction process for the findings to find the significant messages from the text and regarding healthcare professionals' opinions of new handheld ITI-system service process. After the material was placed to generic categories, the researcher tried to find the final findings and then placed the findings again under sub-categories to see the results more efficiently.



Picture 18. Key question areas of the group interview

Healthcare professionals experienced that new ITI-system service process prototype reduced time consumption and produced more accessibility for the healthcare professional work (Figure 6). Healthcare professionals experienced that new ITI-system service process prototype increased working comfort and especially new wizard innovation was seen to be beneficial to verify healthcare professional work process when ITI-system were used.

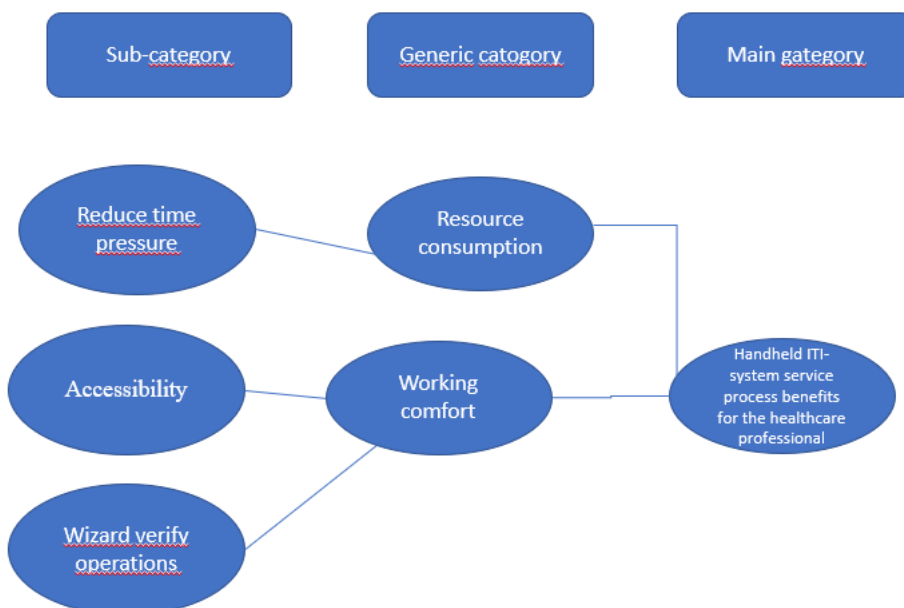


Figure 6. Benefits of handheld ITI-system service process after Abstraction process based to Elo and Kyngäs (2008, 110).

Healthcare professionals experienced that new ITI-system service process prototype could bring resource consumption challenges for the treatment facilities where healthcare professionals work (Figure 7). Space solutions can vary and wheelchair usage can be impossible in some places. Healthcare center space solutions should have accessible spaces for the wheelchair-shaped chair. Healthcare professionals experienced that new ITI-system service process prototype would maybe face some operational challenges. Patient can exposure the feet while waiting and without the healthcare professional noticing. Healthcare professional experienced those technological solutions can be difficult for older people to use.

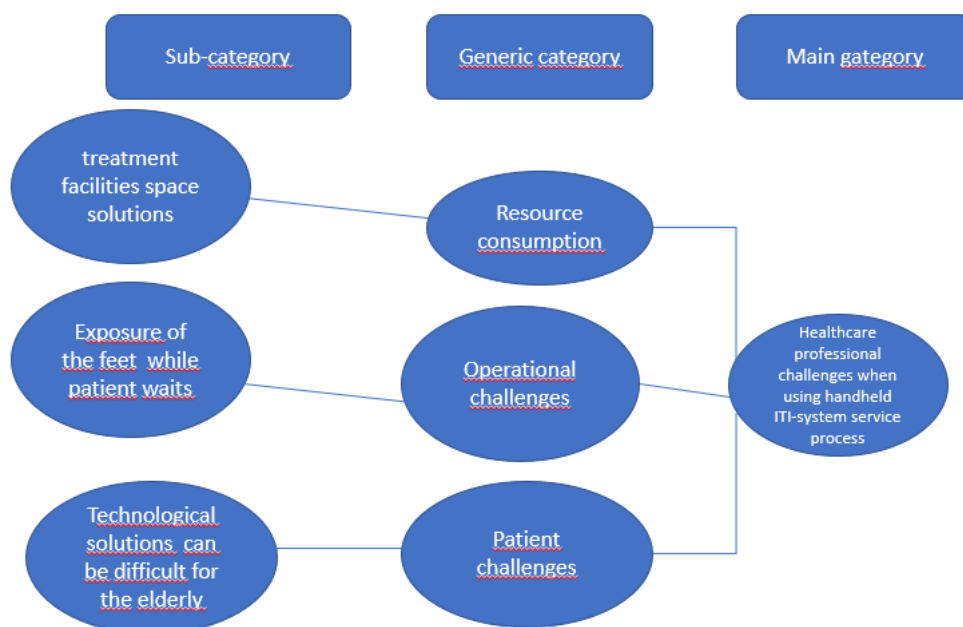


Figure 7. Challenges of handheld ITI-system service process after abstraction process based to Elo and Kyngäs (2008, 110).

Healthcare professionals experienced that new ITI-system service process prototype would give resource possibilities by decreasing time pressure and supporting healthcare professionals' own know-how and trustworthiness when ITI-system was being used (Figure 8). The new handheld ITI-system service process was seen to make

the healthcare professional work easier and more customer friendly. Swivel optics made healthcare professional work smoother because the right imaging angle was easier to find.

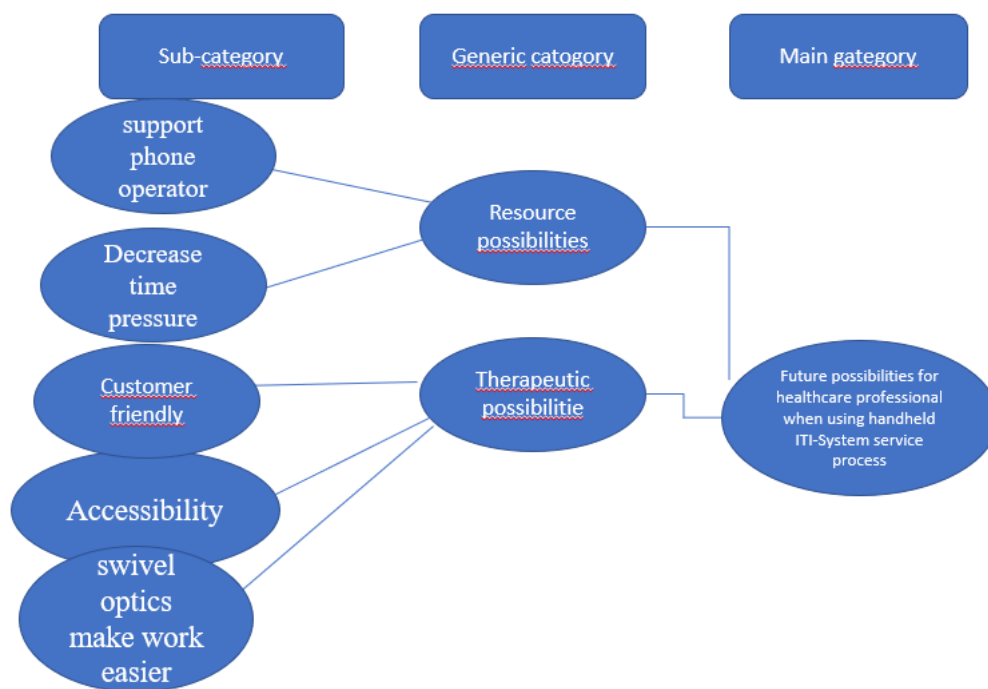


Figure 8. Future possibilities of handheld ITI-system service process after abstraction process based to Elo and Kyngäs (2008, 110).

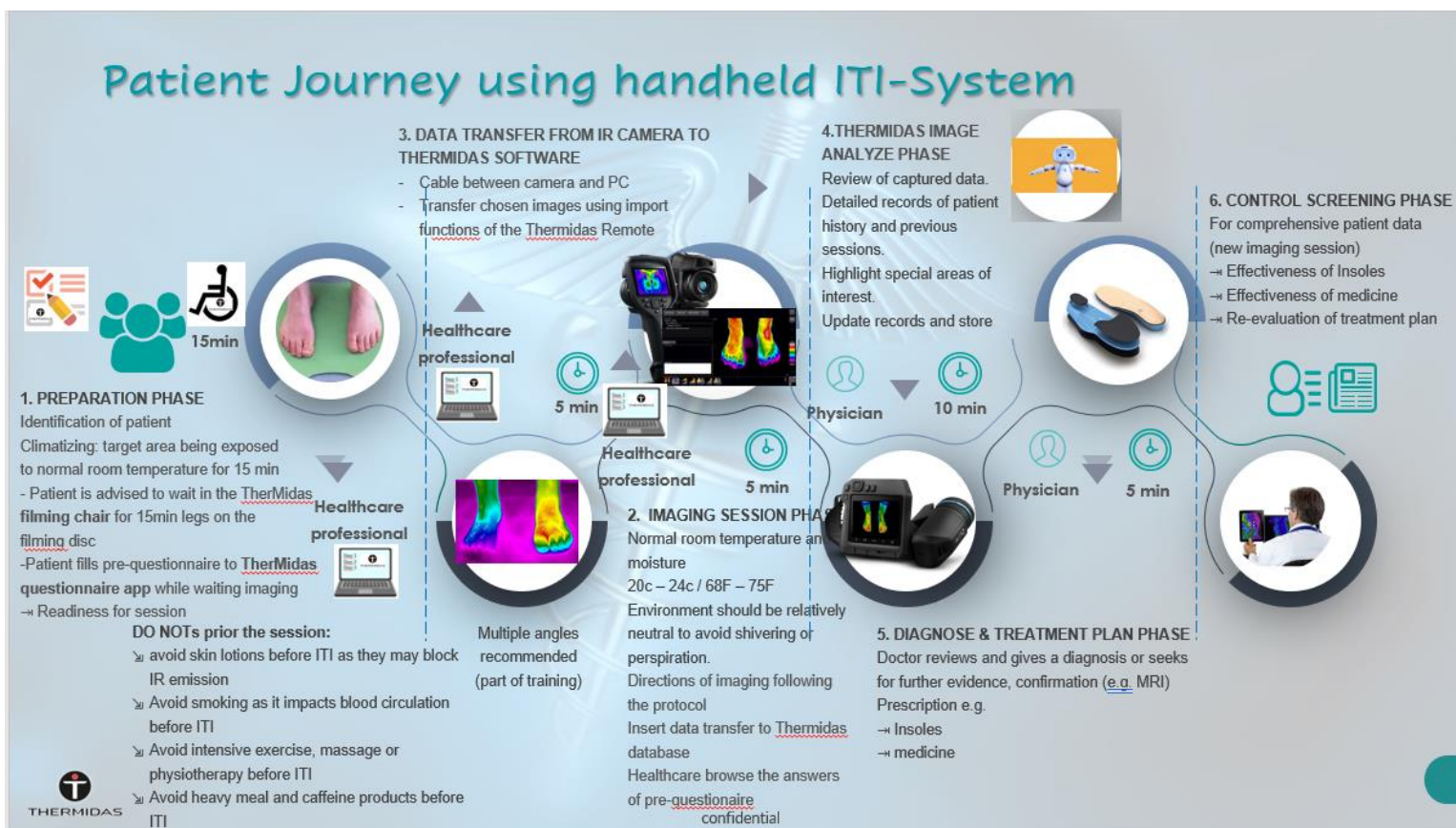
6.4 Phase 4 – The new service process for handheld ITI-system

Based to the research results four new innovations (Picture 19) were created to the handheld ITI-system service process (picture 19). When creating service process for the handheld ITI-system, researcher was focusing on the end user, healthcare professional. Researcher also needed to consider what is the patient's opinion about the treatment she/he is undergoing and how they want to be treated with handheld ITI-system. Especially with medical care, it is important to have a clear image what to do with specific tools and well-thought-out user experience is in the center of the overall contentment.



Picture 19. All new innovations of the handheld ITI-system service process

TherMidas had only certified infrared thermal imaging course and CE-labelled infrared thermal imaging device in the world. Therefore, it was critical to develop a functioning service process (Picture 20) around the new device to have a positive reaction to new technology. When the service design has been made properly, it also ensures that the device is used as it is supposed to and therefore the treatment situation and the new tool will please both the user and the patient. All practical actions were based on researched data. This means that all the actions the user took needed to be research based and justified.



Picture 20. Handheld ITI-system service process after development process

6.5 Phase 5 – Implementation and future

TherMidas is a rather old company to be a start-up company which has made many innovations during their journey in welfare technology industry. It isn't easy to find a way to be a new imaging service and to be approved in the hospital sector, but TherMidas has went forward every year since 2008.

TherMidas company professionals can see a breakthrough in the near future and this research suggests fresh innovations to their product assortment. It will be their decision what kind of handheld ITI-system service process they want to bring to market and continue, but it is sure that all innovations made in this research have gained and used real healthcare professional's opinions.

7 DISCUSSION

Sippola (2021, 9) states that measuring body heat is the oldest measure of health used in medicine. Still in this day, measuring body heat is not included to the risk rating of diabetic legs (table 1) but is a routine check made to diabetic patient by a healthcare professional.

Petrova (2019, 95-103) states that ulcers can be missed during routine healthcare professional assessment if the body heat is not measured with care and ITI could be useful tool. Ilo et al. (2020, 105) clarifies that ITI is a good way to detect side-to-side and local temperature differences which are pathological signs of diabetic complications.

Dealey (2005 159-162) points out that the patient should always have a full foot check at the diabetic clinic and this his must be done by the healthcare professional which is specialized to chronic wounds. Sippola (2021,9) clarifies that when ITI is used it don't send any radiation but only receives it. What could be better tool for the healthcare professional than a safe imaging device. ITI it safe for the patient and can be used limitless to follow up the diabetic feet ulcers because there is no fear of radiation nuisance.

Edmonds & Foster (2014, 1) compares the progress of diabetic foot ulcers towards necrosis to be so rapid and devastating that it can be compared to the heart and brain attacks and that it can quickly reach the point of no return. There are proven imaging services available to diagnose heart and brain attacks. There is also proven imaging service what can be used to diagnose ulcers. What is the price of patient limb for diabetic patient or for society? What if we could notice the upcoming diabetic feet ulcers by using ITI and eventually reach a point where the healthcare professionals could use ITI in daily basis with high confidence among other treatments. This research has proven and shown healthcare professionals opinions about ITI. ITI is beneficial and helps healthcare professionals and we just need to use ITI more and learn. Just the way we did with other imaging services in the early years of these services.

This research gives answer for two questions: 1) How healthcare professionals experience ITI in part their daily work routines and 2) what kind of handheld ITI-system service process would be beneficial for the healthcare professional in diabetic care.

7.1 Suitability of results

Kielo (2019, 4021) describes that healthcare professional needs to diagnose and react to the need of care based on the symptoms that the patient is or is not experiencing. Dealey (2005, 159-162) underlines that measurement of the ulcer by tracing may not provide adequate information as the surface area may not appear to alter greatly and that photographic record have more value when measuring the progress of diabetic ulcers. ITI gives opportunity to reveal possible foot ulcers which are not met in normal foot check and which the patient is not experiencing. Healthcare professionals described that ITI could be a part of diabetic patient treatment chain and that ITI supports the other treatments well.

Ilo et al. (2020, 105) pointed that ITI is useful as an additional method for screening high-risk diabetic feet. Petrova (2019, 95-103) stated that the ability to detect clinically the initial signs of foot ulcers may be limited, and pre-ulcerative inflammation can be missed during routine healthcare professional assessment. Healthcare professionals answered that ITI would be beneficial tool especially identifying Charcot's leg which is one high-risk symptom of diabetic feet because high-risk symptoms are not always be seen in visible eye or founded in normal foot check. ITI was seen as a good tool in this research to follow up the patient's wounds and same time to monitor other areas so that wounds cannot be created elsewhere.

Service design offers an approach to handle strategic initiatives as well as operational challenges. Reason et al. (2015, 12-13) suggest three questions to assist with service design: What does it do, how will it do it and which capabilities are needed. For TherMida's case, these questions would be: What does new service process for new handheld ITI-system do for TherMidas current and future customers? How will TherMidas company be impacted by having a service process for handheld ITI-

system? Which capabilities are needed for TherMidas to respond or to drive the initiative?

Above questions guided researcher to create a service process for handheld ITI-system for present day need, but also for the future. Some of the new ITI-system service process new parts unleashed modern welfare technology like artificial intelligence. Driving the initiative, after studying welfare technology for two years now, the author thinks that modern welfare technology is still out there but there still some barriers and maybe fears why welfare technology innovations are not yet met more frequently in the hospital sector. Welfare technology industry needs more development innovations to be used and brought to the markets with courage.

TherMidas staff were pleased about the new innovations and there can be chance that these new features will see daylight in near future. This development research is straight related to TherMidas future customers because they are the ones who purchase and use their products. There isn't similar qualitative research done about ITI and about healthcare professionals using ITI. Alhonsuo (2021, 52-60) points out that creating a new service process to hospital environment we need to trust different experts but to be ready to ideate and test different service solutions in these moments and see how they work in real life. Healthcare professional opinions are valuable resource for the quality of the product and for the company image because TherMidas use real experience data when creating their products. This research gives a clear message for TherMidas customers that their products are focused to be user based.

Healthcare professionals experienced that ITI could be sell out as an extra service and ITI was also seen with musculoskeletal disorder clients as part of the initial assessment. There is a need for products in the hospital industry which are safe to use, and which are multifunctional. Sippola (2021, 12) points that results of recent studies of ITI seem very promising to reinforce the role of thermal imaging as suitable outcome measure of novel treatments. Sippola (2021, 12) makes clear that ITI is multifunctional imaging service: ITI of suspicious joints has been used as a useful adjunct methodology for rapid screening and follow-up of rheumatoid arthritis and that ITI have been used to characterize and distinguish between malignant and benign neoplasms and different

skin cancer types. ITI has also been successfully applied in the treatment evaluation of these types of lesions.

Usually, the best innovations are simple and are based on something which is already used but in different ways. ITI is a good example of this kind of innovation because ITI uses the oldest way of measurement method, body temperature. There is a need for products which are safe to use, and which are multifunctional. Healthcare professionals thought that ITI can be expensive investment for the hospitals. Nevertheless, ITI can be used in different units in the hospitals, and this makes ITI-system to be a profitable investment for its buyer.

7.2 Validity and reliability of methodological approach

TherMidas launched a new camera to answer the needs in the field of diabetic care. New camera is more affordable than the cartridge version and user can use it in small spaces and in diverse environments where healthcare professional usually need to work. Comparing to trolley ITI-system service process, diverse environments demand different perspective to look at when creating a service process to handheld ITI-system. The ultimate goal was to have a service process for handheld ITI-system which can be modified to work also outside the hospital. When creating a service process for handheld ITI-system, the real user opinions were very important when the goal was to have a safe and practical service process for the handheld ITI-system.

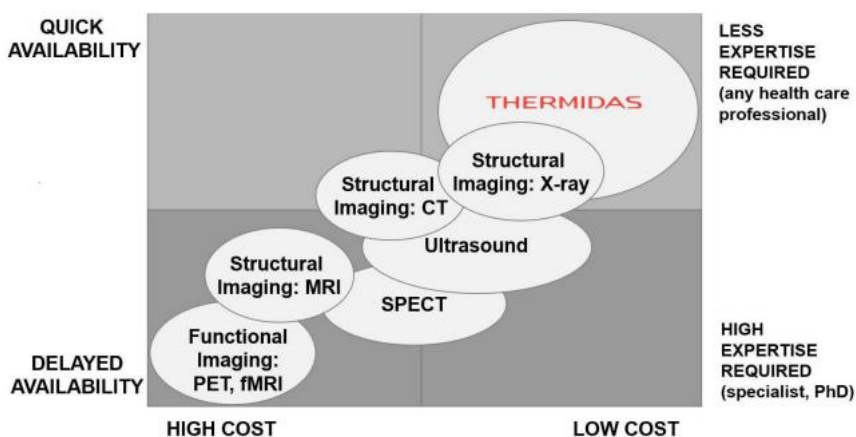
Saunders et al. (2003) points that there shouldn't be a situation where there is no or little connection between the data and the final conclusions. All the new innovations were based to data and researcher tried to make this research as transparent as possible by using many pictures and storytelling through the research.

Saldana et al. (2011,75-76) clarifies that multiple data-gathering methods will give credibility and trustworthiness of a study. Research methodologies in this research were chosen from the need of different perspectives to achieve a service process for the handheld ITI-system what would have been done from as many perspectives as possible. New service process was based on analyzed research results, market scan and

opinions of TherMidas company professionals. For this research, the researcher conducted two interviews among the case company's personnel. The interviews took part during the spring of 2022. The combination of individual and group interview helped to gain feedback from the healthcare professionals through the whole development process, which gave opportunity to see are the new innovations beneficial and then develop the handheld ITI-system service process to right direction.

Individual interview gave chance to bring all individual opinions to the table. Person who answered to the individual questionnaire had time to think the opinions from her/his perspective without no one interrupts. Semi-structured and open questions also gave freedom to write and bring the own professional perspective for the develop process despite the years of work experience.

Market scan gave chance to see is there similarities when other imaging services are used. Researcher thinks that it is interesting to notice that the market scan gave similar results about it benefits than Sippola (2021, 14) made when creating clinical evaluating report for TherMidas (picture 21).



Picture 21. TherMidas position in imaging (Sippola, 2021, 14)

7.3 Ethical considerations

Being an old sale and marketing employee in a target company the author was familiar of the product. Author had also background in healthcare and was, thus, familiar with the principles of the responsible conduct of research in healthcare environment. TherMidas CEO was my thesis informative source. Having background in the target company, gave strength to work. Being old employee in this case, didn't conflict of interest. Conflict of interest means that a person can have a relationship with the matter being processed, people who are a party to it, or with persons who are within the sphere of influence in a solution to be reached on the matter, which might jeopardize the person's neutrality. (ARENE 2017, 2) The research included real healthcare professionals and there was no personal data recorded. The results of the study were used in the design of the service process and in the development of training for professionals of diabetic care and especially diabetic foot care.

Service process for diabetic nurse when using infrared thermal imaging device followed TENK and ARENE guidelines as research was conducted in responsible way. (ARENE 2017, 2). Data presenting, handling and evaluation followed scientific guidelines in all possible ways. While conducting research, other researchers was respected by citing their publications in right way. Thesis plan was approved by thesis supervisors before this Thesis practical phases started. Participants of this study was called healthcare professionals. These participants were selected because they had used handheld ITI-system in their work, and they participated to this research study voluntarily. Physiogeriatrics healthcare professionals were working in Uusimaa region and were involved in diabetic foot care. Regarding individual questionnaire, participants were interviewed anonymously regarding the study in purpose to find answers to research questions. Individual questionnaire was collected with online questionnaire anonymously and participation to this study was voluntary. No personal data register was made in this research.

7.4 Limitations of the study

Elo et al. (2014, 3) states that trustworthy content analysis is versatile and includes trustworthiness of the data collection methods. This research didn't reach that goal completely due to the small number of participants. Although, Saldana et al. (2011, 34) states that many factors will decide how many participants are enough. The quality of the research decides because if there is sufficient interview data or not, whether from one person or twenty, research will have a sufficient corpus for analysis. Both research participants who were interviewed individually and who took part to group interview were healthcare professionals with a solid work history working with diabetic feet, so the quality of the participants was good.

Elo and Kyngäs (2008, 110) points that after well-conducted preparation phase next is all about organizing the qualitative data well and to create research related categories to describe the phenomenon, to increase understanding of the research and to generate readers knowledge about the research. Elo et al. (2014, 3) states that well-made sampling strategy, and the selection of a suitable unit of analysis give trustworthiness for the research. Because of the small amount of the participants, researcher tried to keep the reader on track during the research and to maintain the transparency of the research for the reader by showing the full results of the research and how the research results were achieved.

8 CONCLUSIONS AND FUTURE RECOMMENDATIONS

ITI and TherMidas company main goal is to find a route to be part of healthcare. In the road of becoming one of the imaging ways, this develops research produced service process for TherMidas handheld ITI-system. This research combined real healthcare professional opinions to TherMidas company pioneer's present time knowledge regarding ITI. Researcher didn't find any similar research made about ITI, so it was the first time when ITI user opinions was brought to daylight. It is important bring to daylight the healthcare professionals real experiences and same time market the

product to future customers and especially to potential users. This research also increased knowledge of all joined parties that this kind of tool exists and how is ITI when ITI is compared to other imaging services. The results of this study can be also used when developing the training for diabetes nurses. This develop study and feedback of the potential users were valuable information to support other research results made from ITI. The new handheld ITI-system service process will hopefully attain a reputation to be useful in the future and support TherMidas sales and product service quality.

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Kysymyslomake jalkaterveyden asiantuntijoille

Lämpökuvantamisen palveluprosessin luominen diabeetikon jalkaterveyden seurantaan

Opiskelen hyvinvointiteknologiaa Satakunnan ammattikorkeakoulussa. Hyvinvointiteknologian maisteriopintojen opinnäytetyöni keskittyy lämpökuvantamisjärjestelmän uuden palveluprosessin luomiseen diabetespotilaan jalkaterveyden hoitoon. Tutkimuksen toimeksiantaja on laitteen kehittänyt yritys TherMidas Oy. Tutkimus on laadullinen ja pyrkii avoimin kysymyksiin selvittämään, miten diabeteksen jalkaterveyden asiantuntijat kokevat nykyisen TherMidas Oy:n lämpökuvantamisen palveluprosessin ja sen käytön osana nykyisiä työtehtäviään. Tutkimus pohjautuu ennen tutkimusta esiteltyihin materiaaleihin lämpökuvantamisesta. Tutkimus on kaksivaiheinen ja pitää sisällään yksilökyselyn sekä ryhmähaastattelun.

Vaiheessa yksi diabeteksen jalkaterveyden parissa työskentelevät vastaavat sähköisellä kysymyslomakkeella tehtävään yksilökyselyyn lämpökuvantamisjärjestelmän esittelyn jälkeen. Kysymyslomake lähetetään osallistujille kun tuote-esittely on tehty. Yksilökyselyn tulokset analysoidaan ja tulosten perusteella luodaan uusi jalkaterveyden palveluprosessi lämpökuvantamisjärjestelmän käytölle yhteistyössä TherMidas Oy:n asiantuntijoiden kanssa.

Vaiheessa kaksi jalkaterveyden asiantuntijoille järjestetään ryhmähaastattelu teams- sovelluksessa. Ryhmähaastattelun teema on yhteistyössä kehitetyn lämpökuvantamisen palveluprosessin jatkokehitysmahdollisuudet. Ryhmähaastattelu tallennetaan äänitallenteena ja analysoidaan, jonka tulosten pohjalta vaiheessa yksi luotua palveluprosessia tarvittaessa kehitetään ja luodaan uusi lämpökuvantamisjärjestelmän palveluprosessi TherMidas Oy:lle.

Kyselyyn vastataan nimettömänä ja kaikilta tutkimukseen osallistujilta pyydetään kirjallinen suostumus tutkimukseen osallistumiseen. Henkilötietoja ei tallenneta ja tutkimustulosten analysoinnin jälkeen tutkimusmateriaali sekä tutkimuksen tekijän muistiinpanot hävitetään. Tutkimus on vapaaehtoinen ja siitä on mahdollista vetäytyä missä vaiheessa tutkimusta tahansa. Tutkimukseen pyydetään sitoutumaan 1.2.-28.03.2022 väliseksi ajaksi.

Suostumus tutkimukseen osallistumisesta:

Allekirjoitus/nimenselvennys _____

Kiitos tutkimukseen osallistumisesta!

Ystävällisin terveisin

Mikko Heino

1. Jos mietit tämän hetkistä diabetespotilaan hoitopolkua, millä tavalla käsikäyttöinen lämpökuvantamislaitte mielestäsi kehittäisi nykyisiä diabeteshoitajan mahdollisuuksia tukea diabetespotilaan jalkaterveyttä?

2. Jos mietit omia työtehtäviäsi diabetespotilaan hoitopolussa liittyen diabetshaavojen hoitoon ja ennaltaehkäisyyn, mitkä asiat näet haasteelliseksi käsikäyttöisen lämpökuvantamislaitteen käytössä osana työtäsi?

3. Jos mietit omia nykyisiä työtehtäviäsi ja tilannetta, jossa käsikäyttöinen lämpökuvantamisjärjestelmä on yksi työvälineesi, minkälainen olisi mielestäsi optimaalinen ja realistinen hoitajan toiminta diabetespotilaan haavojen hoidossa?
