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SOCIAL SERVICES, HEALTH AND SPORTS

DEVELOPING AN IMPLEMENTATION OF DIGITAL ECG FOR NIUVANNIEMI HOSPITAL NEMO-UNIT

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THESIS
Abstract

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ECG has been vital part as a diagnostic tool for cardiac events in healthcare for decades. Digital ECG has been developed and has been used by variety of hospital globally. Digital ECG offers the means to digitally handle and archive ECG data. In Niuvanniemi Hospital NEMO-unit, approximately 50 ECGs are taken a year, and each ECGs are printed on paper.

The purpose of this thesis was to research the possibly to implement a paperless ECG to Niuvanniemi hospital NEMO-unit. That would allow ECGs to be handled and stored digitally and would bring access to them from variety of locations throughout the hospital. The aim of the thesis was to find out was it possible at this state to begin the implementation and discover if there were any barriers. The research data would be used to gather information for future implementation and possibly bring the paperless ECG available to the entire hospital.

Research was conducted using semi-structured interview. Questions were created beforehand and send to the participants of the interview. Participants were invited to the interview. Two set of interviews were held where 5 people were interviewed. Interviews were recorded and after that transcribed. From transcription original expression were transformed to plain expression. Grouping was used to gather similarities together.

Research results indicated that current method of ECG was found outdated. Paper ECGs have been difficult to handle since they need to hand deliver to specific location, and they are copied for archiving. Some cases paper ECG has been missing. Changes to the current ECG method would the participants want to make it more accessible. Digital ECG would need to have the ability to archive the ECG digitally which would make them more accessible. In some cases, the current method of ECG was described sufficient since there was no knowledge of another method. Digital readiness was seen in a poor condition from nurses' point of view, but there have been network and background systems constructions.

Research results showed that financial situation and possible training would be seen as a possible barrier that would impact the implementation of the digital ECG. There would be need to research the quantity of ECG taken that would be used in a project plan that would be presented for possible financing. There is a need for digital ECG since the physical archiving capacity is running low and construction of another physical archive location is expensive.

Research results could be used in future projects to research the effectiveness and usefulness of the digital ECG when it has been successfully implemented.

Keywords
ECG, digital ECG, digital health, digitalisation, implementation, qualitative research

CONTENTS

1 INTRODUCTION

ECG has been used in healthcare for many decades and it has been rooted as basic function when diagnosing patients' heart activity. It is a vital instrument to study and detect cardiovascular diseases. The ECG monitoring systems have evolved during these years to meet the requirements of today's healthcare. ECG monitoring systems have been updated with various smart and helpful technologies. Devices come in different sizes for different locations, and they can be designed to transfer data via communication technology diminishing the need for printing ECG on paper. (Serhani, Kassabi, Ismail and Navaz 2020)

Niuvanniemi hospital has ECG monitoring systems that are used regularly. Every ECG is printed on a thermal paper which then is showed to the doctor who treats the patient for evaluation. ECGs are taken, in the NEMO-unit, around 50 times in the year 2022 and every single one is printed on a paper. The number of ECGs taken in the entire hospital is larger but there are no statistics taken. (Niuvanniemen sairaala 2023). The evaluation is not instant and there is a possibility the paper will damage or gets misplaced. The evaluation mostly happens during the doctor's rotation at the ward which might happen from hours to days.

The ability to store digitally ECG data would be beneficial for the nursing staff and for the doctors. Digital ECG would mean that they are securely stored and be accessed from number of locations in the hospital. Digital ECG can be referenced with each other more easily. Digital ECG would also mean no more paper archiving since ECG paper can worsen over time. Thesis client organization is Niuvanniemi NEMO-unit

The purpose of this thesis is to research the possibility to implement a paperless ECG to Niuvanniemi hospital NEMO-unit. In that way, ECGs would be handled and stored digitally and would be accessible from variety of locations throughout the hospital for doctors to evaluate the EGCs and for nurses to upload them. The aim of the thesis is to find out is possible at this state to begin the implementation or are the any barriers. The research data would be used to gather information for the future implementation and perhaps make the paperless ECG available to the entire hospital. Research result can be used to consider the possibilities of digital ECG in other facilities, or it can be used to for other medical imaging digital implementation.

2 BACKGROUND OF THE STUDY

Digital health has been associated with several different factors and it differs from different perspectives, but it is shown that digital health consists of e-health, telehealth, telemedicine, wearables, sensors, information systems and medical imaging systems. In addition of using digital data to form digital health basis, nondigital data is also relevant. Digital health term was firstly used in making health records digital in the 1990s. Today artificial intelligence is more used in everyday life and in healthcare settings. (Fatehi, Samadbeik, and Kazemi 2020)

Digital health has been visualized to bring easier access to healthcare, weaken the disorganization in healthcare, better care quality, reduce costs and give individual healthcare. Digital health has become important in the evolution of medicine and healthcare. It is important to for everyone who has access to digital health to share knowledge and experience through the evolutionary phases and adaptations. With all the advantages in digital health age there are concerns about the misuse and safety of patient health data. There are also numerous sites that has misinformation about regarding to healthcare that are not associated with healthcare. (Ronquillo, Meyers and Korvek 2023)

Digital skills are important part of nurses' role in today's healthcare. Finnish Nurses Association's strategy for digital social and health strategy aims to provide guidance for quality of care via digital services. Nurses have important role in healthcare and strategy goal is to support their work with digital tools. Strategy also brings forth nurses' role in using and developing digital services and promoting their role as key figure in digital services users. Strategy promotes that nurses need adequate digital skills. (Finnish Nurses Association 2021)

Research for registered nurses as a digital customer worker in healthcare and social welfare was conducted in 2023. Registered nurse's digital customer work include communication with customers/patients, video conferences and treatment promotion in an indirect contact. Research study results show that there are variety of digital services provided in healthcare and social welfare. Registered nurses did digital work were done part of nurse's other work; hence digital work was not done primarily. Study showed that there are registered nurses that did digital customer work daily but also ones who do it less. (Kainiemi, Kyytsönen, Kaihlanen, Virtanen, Heponiemi, Vehko 2023)

Role of healthcare professionals has changed throughout the years with more digital and technological advancements have come important part of the daily routine of healthcare. Healthcare professionals today need digital skills and be adaptive to changes in their working environment. The skills require to use technical devices that use telemedicine, mobile devices and wireless systems and understands about data and its safety. New advantages in healthcare means new responsibilities. Training is a substantial part of learning and maintaining digital skills. (Isidori, Diamanti, Gios, Malfatti, Perini, Nicolini, Longhini, Forti, Fraschini, Bizarri, Brancorsini and Gaudino 2022)

Healthcare professionals' competence for digitalisation need to have proper knowledge and expertise to utilize digital tools to provide good care. Healthcare professionals also need adequate social skills for using digital tools for health prevention, motivation, and readiness to add digital technology to their work. Peer and organizational support are also needed to gain positive opportunities while being a part in digitalisation. Healthcare professionals' attitude influences the digital implementation

(Konttila, Siira, Kyngäs, Lahtinen, Elo, Kääriäinen, Kaakinen, Oikarinen, Yamakawa, Fukui, Utsumi, Higami, Higuchi and Mikkonen 2018). Healthcare professional's competence also needs to have knowledge of to use digital technology together with traditional method of treatment. To evaluate what form of digital tools are suited to work together with traditional ways. (Jarva, Oikarinen, Andersson, Tuomikoski, Kääriäinen, Meriläinen and Mikkonen 2021)

Finnish experts have perceived that in the next decade various of digital technology will be come into use. In these include making patient participation easier, service organization and automative data collecting. The use of artificial intelligence is also expected to grow. (Lee, Hammarén and Kanste 2024)

WHO Global strategy on digital health states that its function is to reinforce the adaptation of digital health from consumer to industry. Health data is categorized as being sensitive personal data which requires standardization of safety and security. Transparency is vital in the advancement of data security and communication is important. The strategy shares information about the digital health role as important part of health system. Trust is vital when handling patient related information and sharing them needs to happen with consent. Digital health will improve the quality of care and build information centers that communicate with other systems. (World Health Organization 2021)

European Commission is supporting the digital health development. They see the digital potential towards businesses and people for making better access to health services. eHealth Digital Service is aimed to give EU countries more access to data. Firstly by 2025 it is aimed that every EU country is in digital prescription and patient summary exchange. Secondly is targeted for sharing data for health research and health quality improvements. Thirdly to give an individual EU citizen more access and better care through digital services. (European Commission s.a.) European Commission manuscript about digital future states that, digital health records in a format for transferring, that these records can be accessed and from different parts of the EU and data sharing for creating better treatment to different illnesses. (European Commission 2020.) DigitalHealthEurope is a project that was formed to support these steps that was mentioned earlier. (DigitalHealthEurope 2024)

Ministry of Social Affairs and Health (STM) has made a strategy guide for digitalisation and information management for healthcare and social welfare settings. Its aim is to have citizens with more changes to participate in their own care of health or managing relatives care on their behalf. Using suitable digital solutions for taking care and prevention support individually. These solutions need to be easy to use and personalization is an option. Services come digital by degrees and individuals can have access despite the time and place. While introducing more technology advancement to make service better for patients and customers, the goal is also to help minimizing the task burdens for healthcare professionals. Information about care and health will be accessible for healthcare professionals for analyzing treatment plans. Developing functional systems and making legislation changes to reduce the burden of tasks. The strategy prepares for national and EU legislation for digitalisation for information sharing and information from citizens to be integrated into healthcare systems. (Ministry of Social Affairs and Health 2024a)

An act for use of secondary health and social data was enacted in 2019. Its goal is to gather and handle data from health and social care. The act states that the gathered data will be processed safely. The data is used to help in the development and research in the health and social care settings. It's also stated that the assurance of individual data and they have freedom and right concerning their data. (Ministry of Social Affairs and Health 2019)

The Sustainable Growth Programme for Finland is set to make access to health and social service better. The Programme aims to shorten the upper limit of waiting times for public health and introduction of new digital services. (Ministry of Finance s.a.)

DigiIN is a cooperation project with Finnish Institute for Health and Welfare (THL), Aalto University, University of Helsinki, University of Jyväskylä, Laurea University of Applied Sciences and Age Institute. Project's goal is to remodel healthcare and social sector service culture, digital service of everyone and most vulnerable people's exclusion prevention. The project will use different research methods to find ways to make practical developments for digital evolution. (DigiIN 2021)

Helsinki University Hospital has developed a website for digital health. It was created from the positive feedback of another of their service, Mental Hub, which was develop for mental health patients in 2009. This has been built with collaboration with other university hospitals, funding offered by Finnish Ministry of Social Affairs and Health and technology was supported from Microsoft, Tieto and Innofactor. This Digital Health village is set to wider the developed of digital services for other healthcare areas. (Digital Health Village s.a.a.) Digital Health Village will offer services for public, digital tools for patients and knowledge for healthcare professionals. (Digital Health Village s.a.b.)

Digital health and digitalisation need to be understood as a new operating concept. Its making healthcare and social welfare into a more diverse. The need to new kind of understanding and handling is needed from the healthcare professionals. Operators need to act new ways to control and use new digital environment. (Ministry of Social Affairs and Health 2024b)

Thesis idea was formed when discussing with the nurse in charge of the EEC/EEG – unit in Niuvanniemi hospital. The idea of turning paper-based ECG into digital form entirely was developed in that discussion. It was also thought up to research if there were any barriers for this kind of implementation that would block the implementation from happening. There were talks about turning paper-based ECG into digital form, but no implementation was performed. This led to the idea of researching into this thesis idea to would it possible to achieve this implementation.

3 ELECTROCARDIOGRAM (ECG)

Electrocardiogram (ECG) is the most used way to diagnose patients' cardiovascular activity. It records heart activity from the surface of the body and is non-invasive. It can detect different conditions in the hearth including arrythmia, heart failures. ECG use is simple and because of its size it is mobile and easier to operate. (Reichlin, Abächerli, Twerenbold, Kühne, Schaer, Mueller, Sticherling and Osswald 2016; Satter and Chhabra 2023)

The ECG was invented in 1902 and arrhythmias and changes in the ECG were discovered in 1910. The inventor of ECG, William Einthoven, was awarded a Nobel Prizes of Medicine in 1924. Since then, it has been used globally as a diagnostic tool in many aspects in healthcare. ECG mapping has changed from paper-based to digital electronic signals. In which the ECG evaluation has become more instant. (Sattar and Chhabra 2023; Baydoun, Safatly, Hassan, Ghaziri, Haij and Isma'eel 2019)

Development of ECG monitoring systems have abled them to be used in a broad variety of ways. Due to these advantages, they have been able to utilize in different healthcare settings which included healthcare sectors, in ambulatory settings, at homes and remote locations. ECG monitoring systems today haven been infused with edge computing, which helps to process data closer to the data source making it processing data faster and with winder quantities. ECG monitoring systems are also imbedded with IoT (Internet of things) in which makes ECG monitoring more cost effective. IoT can be from a vehicle to a smart watch that using internal sensors, application, and telecommunication technology to provide the ability to transfer and receive data. (Serhani, Kassabi, Ismail and Navaz 2020; Badilini, Erdem, Zareba and Moss 2020; IBM s.a.; Accenture s.a.)

ECG monitoring can be performed real-time or using Holter monitor for longer monitoring purposes. Implanting a recording monitor under the skin is also a method to record ECG. There are three ways that ECG can be recorded: resting, exercise or portable. ECG is recorded using electrodes that are put on patient's chest, arms, and legs in a specific placement. (National Health Service 2023; Mayo Clinic 2022a, Mayo Clinic 2022b)

Resting 12-Lead ECG is the standard placement to record ECG which is done when patient is lying still. There are other ECG leads; 3-lead, 5-lead, and 15-lead. ECG monitoring system has 10 wires and designed to specific place in a human body. 6 (V1 – v6) electrodes are placed on the chest. 4 electrodes are placed on both arms and ankles. The lead placed on the right ankle serves as the neutral which does not provide any specific part to the ECG recording (FIGURE 1). (Standford Medicine s.a.; Nuttall, Merren, and Sandoval 2023; University of Nottingham s.a.a.; Vogiatzis, Koulouris, Ionnidis, Sdokos, Pliatsika, Roditis and Goumenakis 2019)

There is a room for error when using electrodes on a human body. If the person skin is moist, it will cause the electrodes to loosen and come off easier if the person is moving. Electrodes can dry out if not used in the recommended use time. The placement should be clean before placing electrodes. Using an alcohol pad to clean the area and let it dry. In case of person being hairy on the placement are, shaving the placement area might come necessary. (Handzel 2023)

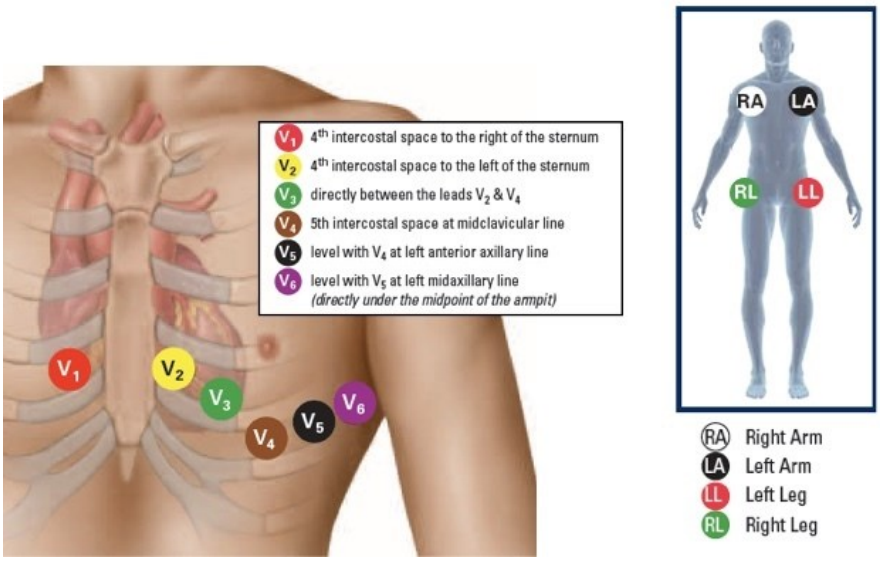

FIGURE 1. Chest and limb electrodes placing (Ernstmeyer and Christman 2023).

When electrodes are placed and the wires connected to the electrodes, then the ECG signal recording can start. ECG detects electrical signals in human body which are caused by nerve and muscle cells. These cells use electrical signals to interact with each other. These signals also are used to manage heartbeat. The sinoatrial node (Sa node) is a cell group located in the right atrium of the heart that send signals which are transmitted through the muscles in a form of electrical impulses. When this occurs, the atria and then the ventricles contract the heart (FIGURE 2). (Institute for Quality and Efficiency in Health Care 2019)

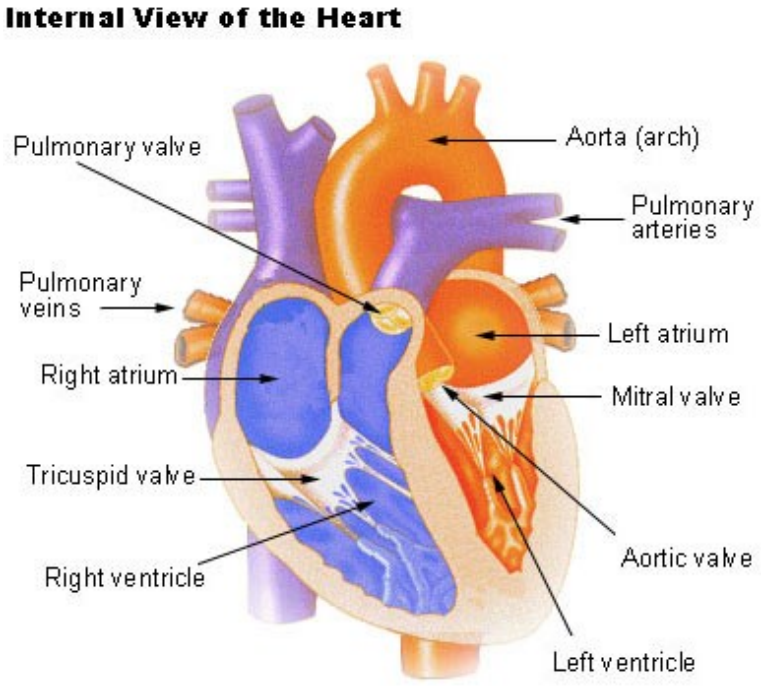

FIGURE 2. Structure of the heart (National Cancer Institute s.a.)

ECG monitoring system records cardiovascular activity by detecting electric signals on the human skin and can display them as waves on the screen of the monitoring system or draw on it on electrocardiograph paper (FIGURE 3).

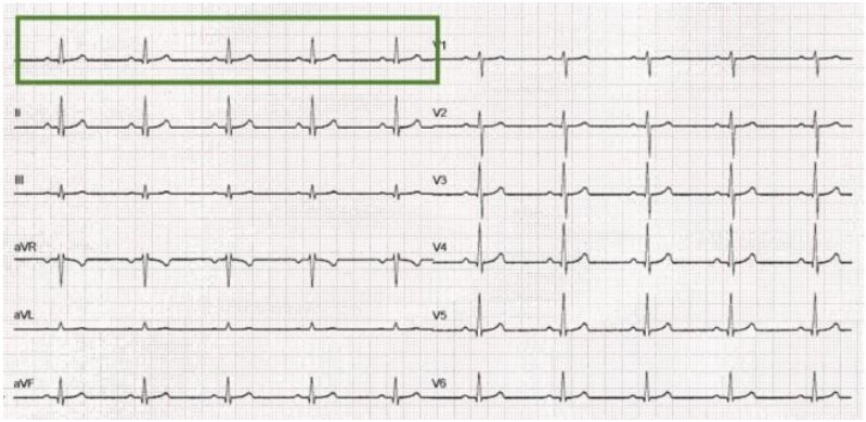

FIGURE 3. ECG on a paper (Randazzo, Puleo, Paviglianiti, Vallan and Pasero 2022).

Paper speed in standardized in 25 mm/sec. ECG paper consists of squares. 1 square on the paper is 1 millimeter in distance and 40 milliseconds in time on a horizontal axis. (Yassar and Lovely 2023; Mayo Clinic 2022; Cadogan and Buttner 2022)

3.1 Digitized and Paperless ECG

In recent years the development of digitizing tools of ECG has emerged and are available for clinical use. There are still cases where ECG is recorded on paper. Digital ECG should be compatible with different systems. The data must also be stored securely, and patient privacy should be important to secure. If an ECG is in not in digital format, it cannot be viewed within patient information system, archived for later use or to transfer and receive it from another healthcare provider. Cloud-based ECG system offers storing and handling the data in the cloud server. Machine learning has been imbedded to IoT based monitoring systems. ECG image can be evaluated from anywhere in the facility. (Serhani, Kassabi, Ismail and Navaz 2020; Badilini, Erdem, Zareba and Moss 2005)

Digitized ECG will be recorded on an ECG machine and then transferred to a software which has a cloud storing functions. The software then also will provide the viewing and evaluating for doctors. In some cases, the software will provide preliminary results which then will be confirmed or researched by the doctor. (Marouf, Vukomanovic, Saranovac and Bozic 2017)

An ECG that was taken by emergency services which showed ST-elevation myocardial infraction (STEMI) was missing when patient was inducted into hospital. New ECG did not show signs of previously mentioned infarction. Patient laboratory tests proved the next day of myocardial damage. Proper estimate of the ECG results and proper transfer of the ECG could have been the key elements of active proper preparation on treating STEMI. (O'Conner 2018).

Paper ECG can be used to be digitized with an MATHLAB based functions. Comparing digital ECG with a past paper-based ECG can prove quite a challenge. Digitized version of ECG which was reconstructed from an original paper-based ECG was deemed in a very close comparison. (Randazzo, Puleo, Paviglianiti, Vallan and Pasero 2022).

Paperless ECG can provide less errors when handling and copying in it and there is less archiving material when ECG is not printed on paper. In due time the printing on the paper will disappear, making in it unreadable. Paperless ECG does have cost effect impact on the hospital's functions. (Lim 2023). Benefits of digitized and paperless ECGs are shown in TABLE 1.

TABLE 1. Digitized and paperless ECG benefits (adapted from Serhani, Kassabi, Ismail and Navaz 2020; Badilini, Erdem, Zareba and Moss 2005; Marouf, Vukomanovic, Saranovac and Bozic 2017; Lim 2023)

Can be accessed from various terminals that are connected to ECG storing system	Archiving is more advanced
ECG can be transfer and down-load on destined digital storage quickly	Digital ECG does not wear away
Certain softwares are imbedded with AI or various ECG interpre-tation features	

3.2 ECG file formats

Technology developments have given many opportunities how to handle ECG signals in storing, transferring, and evaluating. File formats make the ECG data digitally accessible. There are numerous ECG file formats that are in use, but the most common are XML, PDF, JSON. eXentsible Markup Language (XML) is the commonly used data format for storing ECG data. It is simple to use, and it communicates with different protocols and applications. There are different XML-based formats developed for example Phillips XML and HL7 aECG. Phillips XML is used on their own brands ECGs, defibrillators, and monitors. HL7 (Health Level 7) aECG (Annontated ECG) is a medical data digitization standard which supports storing and displaying ECG data. It was created by HL7 Regulated Research Information Management to meet FDA's needs for digital waveforms and measurements. (Cuevas-González, Garciá-Vázguez, Bravo-Zanoguera, López-Avitia, Reyna, Zermeño-Campos and González-Ramírez 2022). Health Level Seven (HL7) standard is for transferring data between patient information systems. It has had a role for interoperability in healthcare and forming electronic health records. HL7 can instruct and give formats for data transfer and messaging, support, define health data in documents. (Sutner 2015; HL7 s.a.).

JSON (JavaScript Object Nontation) was created by Douglas Crocford in 2002. It was designed from the need to transfer data with web services which were based on JavaScript programming language. PDF allows storing on the same file the ECG data and the ECG graphical report. In this form the data is portable, can be archived for longer periods and documentation is easier. The data is not dependent on software or operating systems. (Cuevas-González, Garciá-Vázguez, Bravo-Zanoguera, López-Avitia, Reyna, Zermeño-Campos and González-Ramírez 2022)

DICOM file format is different to types of image formats. A single file includes a header and image data sets. The header includes patient information and specifications about the study. The data is in the form of 0s and 1s until the header organized these into an image (TABLE 2). The header and the data sets are always in the same DICOM file. If separated, the image viewing does not work. (Varma 2012) DICOM standard was first developed for radiology and later for cardiology. DICOM standard today can support electrocardiograms (ECG) and electroencephalography (EEG). DICOM also archives and shares data from images, observations, and reviews.

TABLE 2. DICOM file structure (adapted from Varma 2012)

Preamble (128 bytes)
Prefix – "D"," I","C","M"

Header:
Data set
• Group 1
  ○ Element 1
  ○ Element 2
  ○ etc.
• Group 2
• Group 3
• etc.

Image Pixel Intensity Data: 100110110… etc.

For medical images to be stored, shared, and used they must be in standardized format. DICOM images contain metadata and pixel data that are inserted into a file. (Larobina 2023) DICOM standard has been used in Finland from the beginning. In the year 2000 saw the rise of first filmless hospitals. (Reponen, Keränen, Ruotanen, Tuovinen, Haverinen and Kangas 2022).

3.3 Standards and policies

Digital Imaging and Communications in Medicine (DICOM) is an imaging standard that is international for medical image storing. It also for communication of data among systems that perform medical imaging. It has been a standard for medical imaging for over 30 years. (Larobina 2023)

Picture archiving and communication system (PACS) has over the years surpassed the older format of storing radiology images of hard discs. PACS has introduced a discless format of storing images. PACS has had a positive impact on healthcare organizations efficiency. (Bruthans 2020; Abbasi, Jabali, Khajouei and Tadayon 2020)

A new ECG standard is under development called IEC/CD 80601-2-86.2 for ECG equipments. Its purpose is to safety and fundamental performance of ECGs which include equipment needed for ECG from cables to monitors. This new standard is purposed to replace previous standards that are for ECG equipment. (ISO s.a.; Young and Schmid 2021)

Ministry of Social Affairs and Health dictates the path which social- and health services will follow, guides renewal of service structures and prepares the legislation. Municipalities have responsibility to arrange social- and health services but the providers can span from public to third sector providers. (Virtanen, Smedberg, Nykänen and Stenvall 2017).

National Supervisory Authority for Welfare and Health (Valvira) supervises that the needs for social- and health client and patient data processing meet the needed requirements. Service provider is responsible for meeting and maintaining these requirements. The main requirements are functionality, interoperability and data and privacy security. It also monitors healthcare services network and information security based on NIS Directive. Valvira maintains a database about information systems that process, stores and maintain client and patient data. It also contains information about transfer system that are linked to Kata Services (Valvira s.a.a; Valvira s.a.b)

Finnish Institute for Health and Welfare (THL) conducts monitoring of digital healthcare and social welfare. Monitoring includes digital service developments, patient information systems and management of information. This will guide digitalisation process in healthcare and social welfare. The research and evaluation were conducted in "Monitoring assessment of social welfare and healthcare information systems services" (STePS, STePS2.0 and STePS 3.0) by THL. (Finnish Institute for Health and Welfare 2023).

Laws also dictate about using patient information which must be followed. Parliament decided laws about data protection, processing patient information and client information. (Tietosuojalaki 5.12.2018/1050 1 §; Laki sosiaali- ja terveydenhuollon asiakastietojen käsittelystä 1 §)

PACS started to form in 1995 after DICOM was implemented in Finnish healthcare organizations. PACS availability has been high since 2007. Due to growing use of PACS had also the impact to adopt electronic patient record systems (EPR). Most of the Finnish healthcare centers are using PACS in various forms. In Finland there are seven different trades names for PACS that are in use in hospital around the country. Digital ECG was used by 100 % of the hospital districts, 90% of healthcare centers and 67 % in private sectors organizations (TABLE 3). (Reponen, Keränen, Ruotanen, Tuovinen, Haverinen and Kangas 2022).

TABLE 3. The availability of digital ECGs (adapted from Reponen, Keränen, Ruotanen, Tuovinen, Haverinen and Kangas 2022)

Digital ECG use		
Hospital districts	2020	100 %
	2017	100 %
	2014	86 %
	2011	57 %
	2020	90 %
	2017	90 %

Healthcare centres	2014	77 %
	2011	62 %
Private services	2020	57 %
	2017	42 %
	2014	36 %
	2011	20 %

Imaging Data Repository (Kanta Services) is a service is for archiving medical imaging data which includes ECG data. It is available for public and private health sectors. It can also be used for retrieving imaging data. The person who has entered the data into the Kanta archive has always access to them. If another healthcare provider is accessing the data, it needs that patient's /client's consent. ECG data has been possible to be archived since 2021. From the year 2024 EGC data has been possible the be archived from laboratory systems. By the Parliamentary decree 703/2023, ECG data must be archived by 1.10.2029. When archiving the data must be in DICOM format. (Kanta Services 2024; Asiakastietolaki 203/2023).

3.4 ECG softwares

There are options for ECG software that are provided with ECG monitoring system providers but also separate software is also available. Fimlab Laboratoriot controls a digital ECG management system provided by MUSE Cardiology Information System. Basic requirements for this are using WebFimlab, a MUSE network and EKG monitoring system that is compatible with MUSE. (Fimlab s.a.; GE s.a.)

Helsinki University Hospital provides digital ECG service called Digi-EKG. This service includes Digi-EKG operating system (NeaLink) which is integrated to the Kanta services Imaging Data Repository and archiving, ECG monitoring systems (Schiller), maintenance and customer support. This service can be used on ECG taken from another ECG monitoring system. (Helsinki University Hospital s.a.).

Neagen Oy provides NeaLink which stored ECG data from ECG monitoring systems. NeaLink system has VNA (vendor neutral archiving) in which it supports the data storing standards and support the organizations method of storage. Neagen Oy also provides Digital ECG which communicates with different manufacturers ECG monitoring systems. They have developed an ECG viewing with HTML-viewer. (Vitec Neagen Oy s.a.)

Sectra Medical provides numerous medical imaging services. One of them is Sectra UniView. It is a web browser-based service, and it provides fast and light access to medical images. Niuvanniemi hospital uses Sectra Uniview for storing and viewing EEG recordings. That is only used in ECG/EEG – unit, that does conduct EEG – examinations. (Sectra Medical 2024)

Powerful Medical offers PMcardio Digitze software that can turn a paper-based ECG into digital format using AI technology. The software can be used with mobile phone or from a computer and the digitizing process is offered to be happen in seconds. (Powerful Medical 2024)

Cloud-Based PACS offers digital storing for ECG using cloud storage. It uses would free from using physical storage locations and bring easier access to cloud storage. ECG recording can be accessed from anywhere by the healthcare professionals. In the more traditional way of taking ECG storing and access have been its difficulties. The inability to quickly access patient ECG could be proved to be harmful to the patient if the situation is urgent. (POSTDICOM s.a.)

3.5 ECG monitoring systems in Niuvanniemi hospital

Niuvanniemi hospital is specialized in forensic psychiatric care and forensic assessment and is assigned to perform court-ordered psychiatric examinations. (Niuvanniemi 2024). Niuvanniemi hospital is one of the two forensic psychiatric hospital, and the other one is Old Vaasa hospital. (Kaare 2022).

NEMO-unit conducts ECT treatments and EEG examinations, and ECG associated to them, and ECGs are done according to doctor's orders and when wards asked separately. ECGs are also done at wards with portable ECG monitoring systems. The staff at EEG/ECG-unit will teach and supervise hospital nurses ECG taking performance. NEMO-unit staff includes one who is responsible on the unit, 2 registered nurses and 2 substitute nurses and unit's doctor. (Niuvanniemen sairaala 2023)

ECG is a common practice in Niuvanniemi hospital. Nursing staff are trained to take ECG when needed. ECG is taken in a yearly control manner, when a new patient has come to the hospital, when administrating new medicine or in acute cases. These devices have a touchscreen, so it is easier to evaluate the connection, and the devices give feedback if one or more electrodes are not firmly placed. The ECG can be monitored from the monitoring systems, the devices will interpret the result and when the ECG is deemed to be acceptable, then the ECG is printed on a paper. The paper is then kept secure and giving to the patients doctor for evaluation.

There are three ECG monitoring systems in use in the hospital. One more stable and two are designed to be movable, so you can bring the ECG monitoring system to different wards in the hospital. Cardiovit MS-2015 is 16 -lead ECG which has a 15-inch color touch screen. It has the capability to transmit data with variety of formats, example PDF and DICOM. (Schiller s.a.a) This monitoring system is designed to be kept in ECG/EEG – unit. This monitoring system is used with patients that come for EEG – examination or in some cases for patients who are in ECT treatment. It is also used for evaluating nursing staff's qualification for taking ECG.

The two smaller ECG monitoring systems are both Cardiovit FT-1. This device has 8 -inch touchscreen. Data transfer from this data is possible via Wi-Fi connection (Schiller s.a.b; Schiller s.a.c). They are designed to portable so you can move them easily from ward to ward. These devices are placed in opposite directions of the hospital complex. They have a designed destination which they are stored, and other wards can loan them on the basis that the device must be returned after use.

4 IMPLEMENTATION OF A DIGITAL ECG

Digital implementation has an impact on the performance of our work and how it changes the way how to do things. It will offer new mindset and angles how to view and perform our work. In the implementation process, the human factor must be addressed accordingly by having the change to understand the positive result of the new digital aspect on their work. Digital implementation will bring more efficacy to the work, perhaps making it swifter and eliminating one process part that has been seen being inefficient in the performance of individual or in the entire organization. Every organization implementation process is its own, they are unique. Gathering information and knowledge will bring more hindsight on how to approach and start your own process. (Thun, Bakås and Storholmen 2022; Parviainen, Kääriäinen, Tihinen and Teppola 2017)

Digitalization has had an impact in healthcare across the nations. It has given the opportunity to patients be more engaged in their own health and see their records via electronic health records (EHR). With the advantages of digital health there are drawbacks to it. People with limited digital skills or who do not have access to it will be left out of this digital process. Shared knowledge and making policies that everyone can have access is important part to make the process of all having access to digital health. (Van de vijver, Tensen, Asiki, Requena-Méndez, Heidenrijk, Stronks, Cobelense, Bont and Agyemang 2023)

In healthcare digital implementation can bring new tools treat patients, quicker ways to diagnose and start a treatment plan, gaining access to patient records quickly. Digital tools bring way to monitor patients' wellbeing while being treated and prevention tools and communicating remotely between patient and healthcare worker. Person can use digital health data to observe it and improve quality of life depending on the data results. Data transfer is the one of the major aspects of digital health. Data can be gathered from different types of sensors, mobile phones, camera, or wearable devices. (Mars and Scott 2022)

Digital health provided variety of new approaches and technological upgrades to healthcare but there are downsides as well. Digital health might have legislation and policy issues. Gathering health information from false online sources or indecent digital services that are not from healthcare professionals may lead to dangerous situations. Data may also be retrieved by hackers if using appropriate software or hardware. Sensors or monitors that are not approved for medical use may have mix results on gaining health data that is reliable and safe to use. (Meskó, Drobni, Bényeu, Gergely and Győrffy 2017)

Need for digital implementation might come from the situations of technology-push or demand-pull. Technology-push is a term used when a provider has been given access to perform a project where technology is implemented in a healthcare area. In this situation the targeted users are not yet familiar with the implementation and there for are not confident on the project. Demand-pull term refers when a problem is found in the work performance and that leads to finding the needed service or a tool to that will help with the founded problem. This will lead to identifying the needed service or tool and people are more like to adapt to it easier. (Shaw, Agarwal, Desveaux, Cornejo Palma, Stamenova, Jamieson, Yang, Bhatia and Bhattacharyya 2018)

World Health Organization (WHO) has developed a guide for digital implementation investment that can be used in an implementation process. It is meant for governments and technical partners to advise a plan for digital implementation. The guide will help how to plan, figure out the budget, how to perform the implementation. The guide also provides information on how to determine the need for implementation. The guide has planned implementation from phases 1 to 7; from accessing the current state to implementing and maintaining. (World Health Organization 2020)

4.1 Technology Acceptance Model

Technology, more so information technology (IT), usage in healthcare has been growing the past years. Technology Acceptance Model (TAM) has been used in study settings in healthcare to study technology acceptance. (Rouidi, Elouadi, Hamdoune, Choujtani and Chati 2022). User acceptance is a pivotal role when considering the possibility of implementation and using that implemented factor in any organization. TAM has the aim to figure out and understand if users will or will not use technology that is intended to be implemented. (Ammenwerth 2019)

TAM was created to with the idea for users to understand and accept use of technology and give theory for testing which would help the developing individuals by gaining insight before the implementation process. Testing the acceptance and measuring motivation from users would give necessary information towards the implantation. This model is intended to be able to define process of motivation between user and system. User motivation is affected by how the system operates and thus influences the use of the product. User's attitude of using implied implemented technology according to this model has big impact on the use. Attitude of using is therefore impacted by perceived usefulness and perceived ease of use. Design features might have impact on perceived usefulness and perceived ease of use. Perceived usefulness is seen as user believes the set implementation would improve work performance and ease of use is seen as using an easier functioning system will increase work performance as seen in FIGURE 4. (Davis 1985)

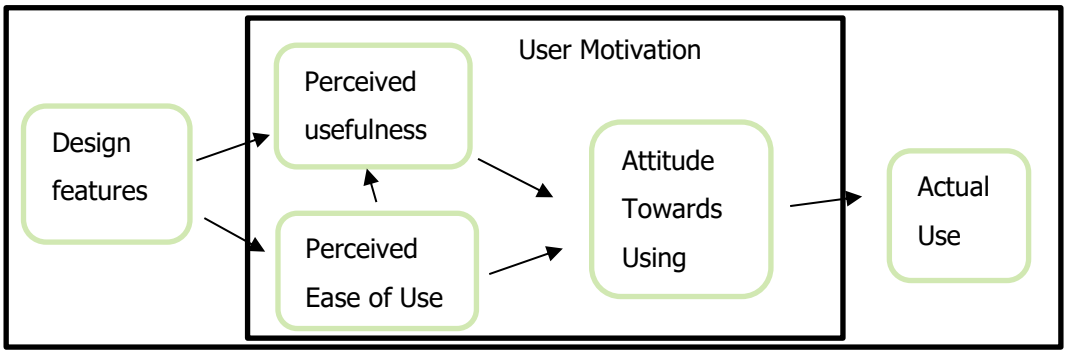

FIGURE 4. Technology Acceptance Model (adapted from Davis 1985).

User acceptance has been the key element in the technological implantation process. It defines if the process has succeeded or failed. TAM has been updated over the years with added components to the model. In TAM 2 had been added components that are shown in FIGURE 5. Social action has an impact in the user's use of a new technology in the form of subjective norm, voluntariness, and image. Subjective norm is described as user's understanding that people who are close to him or her think to do or not to do this way of behaving. Voluntariness is described as voluntary of use not be-

ing forced to them. Image is influenced positively by subjective norm because user's important persons belief on use will change the position of the user in the social group. Experience has been theorized to have a declining effect of subjective norm and therefore perceived usefulness because overtime experience of using system will increase. Job relevance is seen as how appropriate the implied systems function is towards the user's work. Output quality is defined that how does the system perform the designed duties. Result demonstrability is defined that users who have gained positive experience when the relationship of use and the result have positive impact. (Venkatesh and Davis 2000)

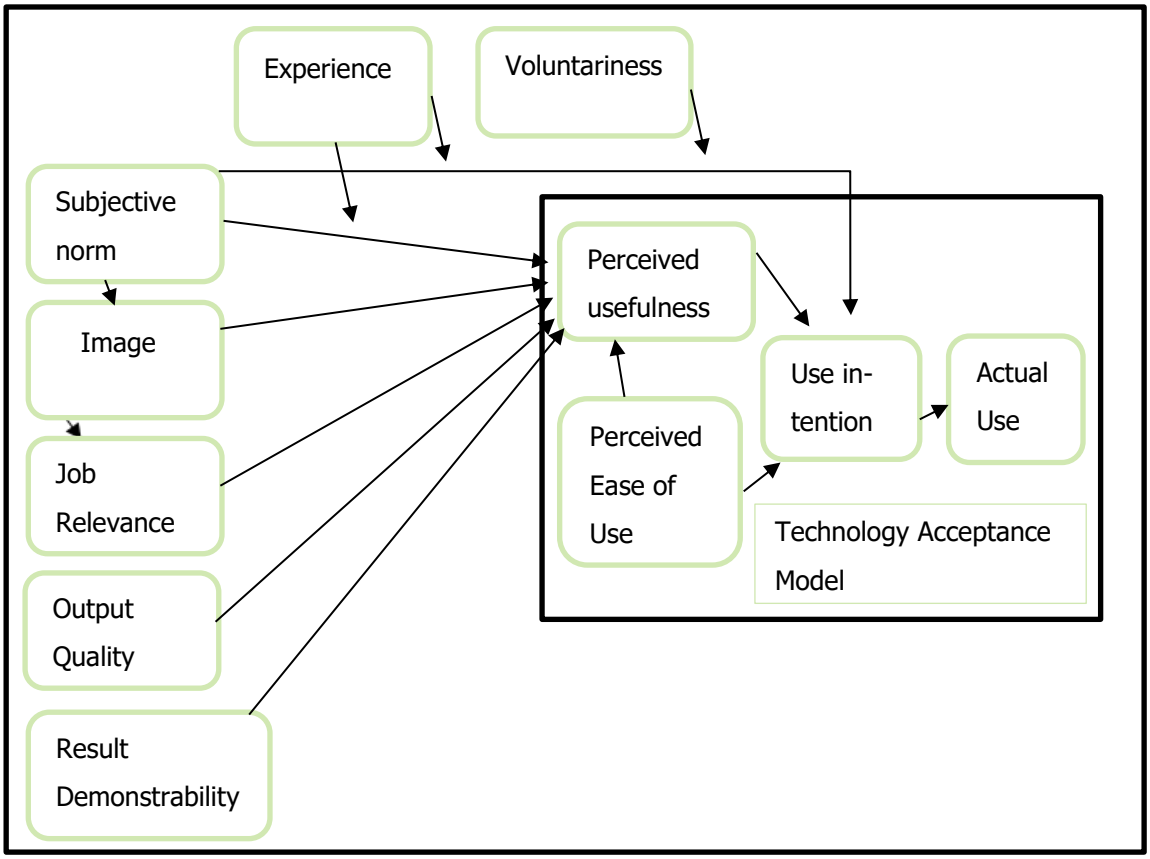

FIGURE 5. Technology Acceptance Model 2 (adapted from Venkatesh and Davis 2000).

TAM 3 has been further enhanced by adding more components to the model. Different experience has an effect towards anxiety towards computer use. Experience gains knowledge on what difficulty is the system use. User with more experience in computer use would have lesser anxiety in using system when user will possess more knowledge on what is needed to do certain duties and will get to know to features will lead to enjoyment. Perceived usefulness was theorized to decline when experience was gained (FIGURE 6). (Venkatesh and Bala 2008)

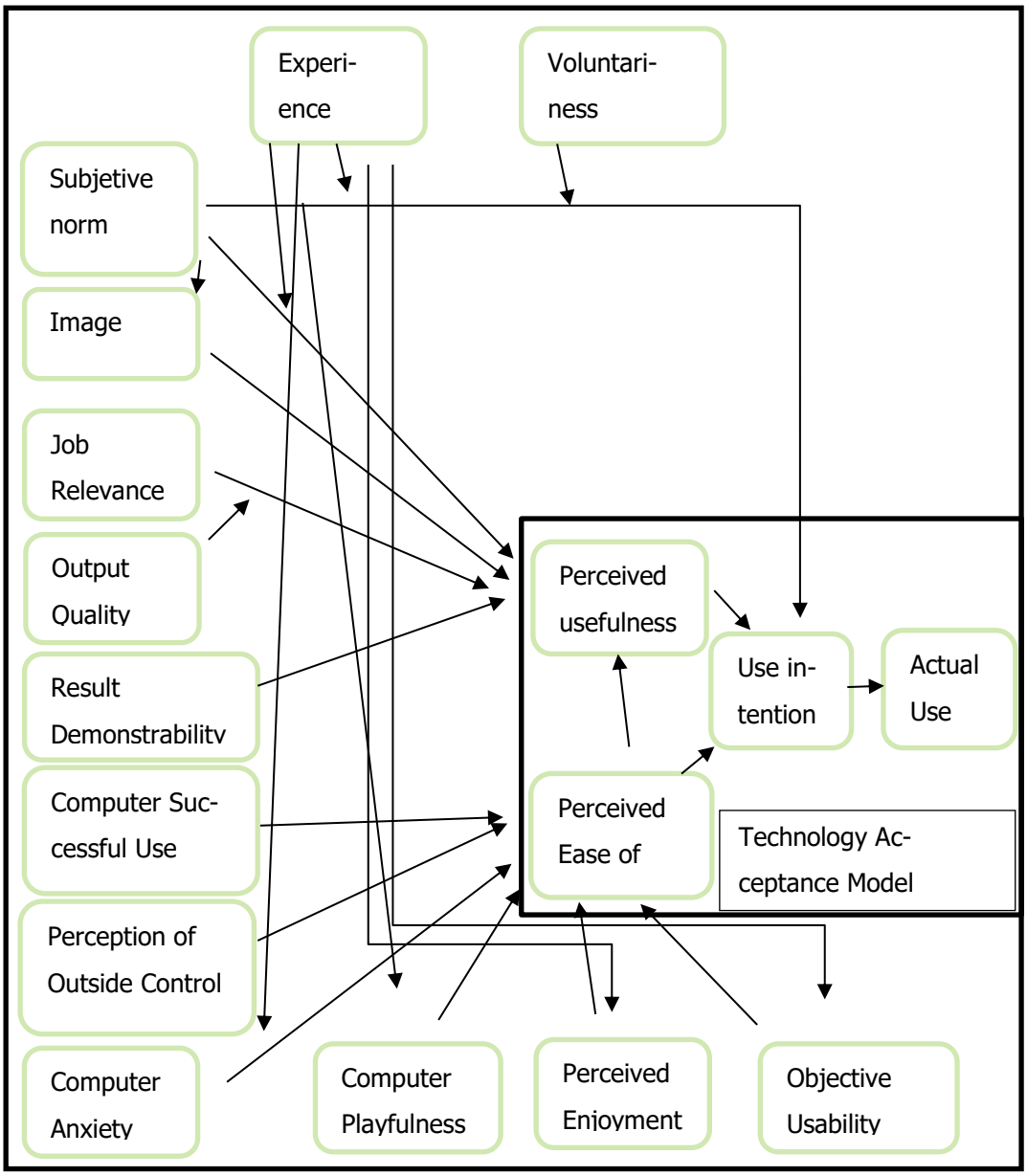

FIGURE 6. Technology Acceptance Model 3 (adapted from Venkatesh and Bala 2008).

TAM has been utilized in a research study of patients experience of using electrical services and evaluate the usefulness and ease of use. A questionnaire was used to gather research data from patients and their escorts at Kuopio University Hospital outpatient clinic in April 2017. TAM model was proved to be useful in the research study. The use of electrical services ease of use was founded to be important and their impact was projected towards perceived usefulness. The study showed that estimated usefulness will have an impact to patient's approach and actual use of electrical services more than ease of use. Technical usability was found to be successful in electronic prescriptions, appointment booking and viewing personal information in which respondents' user experience were related to. TAM model was found to be a strength in the research study. (Kivekäs, Kuosmanen, Kinnunen, Kansanen and Saranto 2019)

TAM model was used to reflect the results of general practitioner's (GP) use of digital tools in Finnish public health centres. The study aimed to examine the effectiveness of digitalisation in Finnish health centres in 2021 and what tools were used. They also studied GPs attitude towards digitalization. Study showed that GPs preferred using telephone call in remote consultations rather than

chat/video and other digital tools were not in daily use. Attitude were found to be positive. Using TAM to reflects the study results, it showed that digital tools were not good or useful enough for GPs. (Kujansivu, Tolvanen, Kautto and Koskela 2023)

On a study that focused on wearable sensors assumed usefulness in early recognition of migraine attacks perceived by patients, TAM was applied to analyze usefulness of a wearable sensor. Data was gathered with questionnaire in which 582 patients answers and 12 people were interviewed. The study found relative data about usefulness of wearable sensors for migraine patients for future studies. That data included user interfaces, medication reminders and diaries. (Huttunen, Seppänen and Halonen 2022)

A tool based on TAM was created and used in a study to determine patients' willingness to use Healthvillage.fi e-services. TAM model was chosen for it would capture the technology use in various ways and taking in account the external factors for example the experience of using e-services. The user acceptance was seen appropriate find. Study showed that patients are reacting positively towards e-services finding them easy to use and useful. Healthvillage.fi was proven to be a needed service. Patients with prior experience found Healthvillage.fi more useful compared to less experience patient. (Saranto, Kivekäs, Kuosmanen, Kinnunen 2018)

TAM was used as a framework for studying the impact of electronic prescribing on patient safety and quality of care and physician estimates of it. TAM model was used to analyze the acceptance of electronic prescribing and how outside variable effect on physicians' work. Study showed that patient safety and quality of care was affected by perceived usefulness of e-prescribing and the thoughts were found positive. TAM model provided information about when gaining experience while using e-prescribing system, it increased patient safety and quality of care and had secondary effect on perceived ease of use. (Kivekäs, Mikkonen, Borycki, Ihantola and Saranto 2018)

A modified TAM model was created in the research of health professionals' acceptance of health information technology. Study showed that healthcare professionals were more accepting when they know the applicability of health information system to their daily work performance. Making applications more accessible and training possibilities would lead more higher acceptance among the users. Study showed that TAM2 was deemed more suitable for healthcare setting studies than the original TAM. (Ketikidis, Dimitrovski, Lazuras and Bath 2012)

To understand the behavioral intention of use, an extended TAM model was used in research that studied acceptance of a wearable cardiac health monitoring system. Study showed that readiness to use smart technology was increased by the perceived benefits of the wearable system. Wearable cardiac health monitors perceived usefulness was parallel with users' positive attitude. (Lin, Ke, Chou, Chang, Tsai and Lee 2018)

Understanding the influence factors of nurses' acceptance of new technology was studied using TAM. Perceived benefits were found to concur in nursing practice. When dealing with changes in technology and facing them, nurses' ability to operate are tested. The decision to use new technology when understating the changes it would bring to their, would enhance their work performance

and quality. Study found that independent changes must be made to accept new technology. (Tsarfati and Cojocaru 2023)

TAM has been applied in healthcare settings for EHRs where system's impact was found to have an impact on use intentions of EHRs. TAM was connected to in the use of telemedicine and communication systems. Study shows that nurses' negative attitude affects the adoption of telemedicine. Recently TAM was utilized in studying mobile technology. It also has deemed that TAM needed to adapt to these new areas of technology. (Rahimi, Nardi, Afshar and Timpka 2018)

In a study for adopting ECG wearable authentication device, extended version of TAM was used study acceptance. Study showed positive correlations with perceived ease of use (PEU) with attitude, PEU towards with perceived usefulness (PU), PEU with attitude and PEU towards voluntary use in using ECG Wearable Authenctication device. (Lahoud 2020)

A modified TAM was used to understand the impact of trust and privacy concerns that effect patient's acceptance towards technology. Study showed that trust and privacy concerns do have an impact on using technology in healthcare. Study found that that trust has major effect on gaining acceptance. Privacy concerns do have negative effect on using technology, seeing technology useful and on adaptation of technology. If privacy concerns are not reduced, it will have influence on the decision using that technology. (Dhagarra, Goswami and Kumar 2020)

4.2 Past Digital ECG implementations

Implementation of the ECG into Maharaj Narkorn Chiang Mai Hospital's patient information system. ECG is used in the hospital in many locations and over 100 ECGs are printed but only few are recorded and archived. ECGs are scanned and transformed to a PDF file and by that way they are included in patient information system. The implementation was staged in two phases. First phase included implementing the ECG recording system by assigning cardiographs to piloting areas and staff that are designed for training. The second phase was to implement ECG Viewing system into their information system. The implementation was successful, and they managed to develop a paperless ECG method. (Khumrin and Chumpoo 2016)

Cardiology and Thoracic Surgery of the Leiden University Medical Center's implemented and developed of a fully paperless information system. Hospital had implemented an ECG system from Draeger Infinity Megacare to their own patient information system to send ECG wired or wirelessly. The implementation brought advantages by making patient charts be immediately available, ECG included. (In van der Velde, Atsma, Schalij and Witteman 2006)

Alb Fils-Kliniken in Germany visioned of going paperless. They began a process replacing older ECG monitoring systems to newer ones and then implementation of MUSE Cardiology Information System. By this, they could save the ECG directly from the hospital bed and the ECG can be accessed from anywhere in the facility, thus upgrading the ECG to paperless. (GE HealthCare 2021)

Swansea Bay hospital received new ECH machines that produce digital ECG signals. This new update is considered to bring more safety to patients care. The ECG can be accessed immediately by healthcare professionals from the hospital. (Swansea Bay University Health Board s.a.)

Diagnostic Center in Helsinki University Hospital (HUS) replaced its digital ECG system and ECG recording devices. Neagen Oy provided the new digital ECG system (NeaLink) together with Medifin Healthcare Oy who provides new ECG monitoring systems (Schiller). Previous ECG system was put in use in 2008, and this new system replaced in fall of 2023. Importance of this replacement was to make it easy to use for users and the ability to store ECG recording and viewing them from different devices. Digital ECG archive has been in use in HUS since 2009. It has made the viewing and comparing ECGs easy, and it has been used for medical research. (Helsinki University Hospital 2023; Helsinki University Hospital s.a; Medifin Healthcare Oy 2023)

A method for scanning and digitizing ECG paper archive was developed using ECG Trace Tool with EASE computer software. Research data was used from Mini-Finland Health survey done by Social Insurance Institution. From that survey were researchers able to gather paper ECGs which were then scanned to a multi-Page TIFF – files. ECG Trace Tool was a standalone software which were used in Windows operating software. The study showed that the process of digitizing ECGs would bring better storing in which in requires lesser storing capacity compared to being in paper form. ECG can be studied with digital measurements more thoroughly. Digital ECG signal was found to be more clearly visible compared to being in paper. (Holkeri, Eranti, Kenttä, Noponen, Haukilahti, Seppänen, Junttila, Kerola, Rissanen, Heliövaara, Knekt, Aro and Huikuri 2018)

ECG was integrated with Norther Health Electronic Health Record (EMR) in September 2023. Before this ECG results were stored in the ECG monitoring devices and were consulted by doctors the morning rounds. ECGs were printed on paper and stored in patients paper records. With this integration ECGs will be stored in an archive and included in the patients record in EMR. (Norther Health EMR 2023; Northern Health EMR 2022)

Research study was performed where an IoT (Internet of Thigs) based ECG monitoring system was designed and implemented based on previous system architecture. This wearable system consists of three electrodes that are attached to the patient. The device offered to collect ECG signal in real time and the accuracy of the ECG signal was found to be adequate. Wi-Fi was used to transfer the collected ECG data to a IoT cloud in which the data is also stored and can be used to visualize the ECG signal. (Yang, Lei, Zhou, and Zheng 2016)

Another study showed cloud computing implemented on acquiring ECG signal and transferring it to a cloud server. The ECG data can be accessed from devices that are connected to a network. Data was protected with cloud providers data securing means by scoping users who are not authorized to access and hiding the data location. ECG data is multiplied and send to another location in the cloud server for retrieving the data. Physician can access the ECG recording for analysation remotely over the web. Trust issues are present towards data security. This cloud-based ECG service can accomplish interoperability with different devices. (Hsieh and Hsu 2012)

4.3 Risks and benefits of implementation

When beginning the implementation process, it should be considered in what way it will have on effect to the entire organization, in what way does it benefit, and will it cause strain other places

and who will the targeted users. Process resources must be knowing in the early stages of the implementation process, which may include integration of IT, training, data security, personnel resources, and current electronic health record system adaptation of the new implementation. There is a risk that when not considering the steps carefully the implementation may end up being incomplete or during the process the interest gets lost. It's vital for the implementation process to have key figures to guide the process and in the adaption into the current healthcare processes. (Marwaha, Landman, Brat, Dunn and Gordon 2022)

Risks may cause halting or entirely closing the implementation process. There are multitude of risk factors that are possible in implementation. Risks may include not engaging the implementing process, the functions of the process fail to meet the needed criteria, process wrongful timing and budgeting risks. (Batkosvkiy, Konovalova, Semenova, Trofimets and Fomina 2015)

One of the main challenges in digital health implementation is interoperability. Technically systems need to be able to communicate to each other and are bound to work how the legislate has them demanded. GDPR (General Data Protection Regulation) has given the conditions in which data must be protected and the operators of the system need to adhere these guidelines. In some cases, organization need to have changes for interoperability to function. (Wong, Maaß, Vodden, Kessel, Sorbello, Buttigieg, Odone 2022)

In any implementation process they are risks of failure or incompatibility between hardware and software. These risks should be carefully evaluated before beginning the process of implementing something into patient information software or another software on its side. There is human, hardware, software, and organizational risk factors. It is important to identify these risks thoroughly, especially with the personnel who are going to be working before, during and after the implementation. Personnel should be trained how to handle the new added software safely and securely. They also need to know how to operate if there is an error while operating. Personnel also needs to have opportunity to give thoughts about what is needed in the implementation and gather the risks inside the department. Software malfunction or hardware crashes will bring delays and add stress. These malfunctions will bring interruptions and build a workload that will also bring more stress. Hastily implemented, less or no time for training and acceptance and not being in the process will also have negative effect. Organization, more closely the IT department, needs to consider is there a possibility to implement a new feature into the patient information software or do you need another software. The security and functionality of the organizations network also needs evaluating in this implementation process. The software must be something suits the need of use and it's not complexed to operate. (Sharifian, Ghasemi, Kharazmi, Farhadi, Monem and Shokrpour 2023; Gutenstein, Pickering and Than 2018; Thun, Båkas and Storholmen 2021)

Users own disbelief and phobias towards technology may be a barrier in implementation. If a person is not ready to change and adapt, the process will not function properly. User might have bad past experiences with technology, low technical skills, or unwillingness to see digital aspects benefits in their work. Supporting and helping using and seeing the beneficial aspects are the key to counter these barriers. Healthcare professionals might see that adding digital tools to their work will reduce

the time with patients and more time using them, hence adding more pressure to work environments. With proper training and knowledge these worries might subside. (Borges do Nascimento, Abdulazeem, Vasanthan, Martinez, Zucoloto, Østengaard, Azzopardi-Muscat, Zapata and Novillo-Ortiz 2023)

GDPR is intended for all organizations to follow their guidelines on data protection. Its purpose is to safeguard data of individuals throughout the European Union (EU). There are seven principles in the GDPR that are accountability, lawfulness, fairness and transparency, security integrity and confidentiality, purpose limitation, data minimization, accuracy, and storage limitation. Wherever the organization is located it will have to process data of the individuals in EU. Not every organization need to have a data protection officer who will guide in the protection of personal data, but it is mandatory if they are a public authority, they involve in large data processing operations that need monitoring of data subjects or they do data processing of special classes of sensitive data for example personal information on health, race, religion, or sexual orientation. (Alford 2019)

Legislation and policies inside and outside the organization may influence the implementation process. Certain policies may work as and barrier for the process if not met with the requirements or the policy does not yet allow certain processes to forth. Implementation process may be affected by different sorts of policies within the organization and/or what effect the organization itself and how the government has stated the legislations. Financial situation is considered one of the barriers in digital health innovation. (Desveaux, Soobiah, Bhatia and Shaw 2019)

To get past these barriers especially financial barriers, there should be strategy model to be made where the implementation process is laid out with how it would financially benefit the company while making remarks of the costs of the implementation as well document the need with gathered evidence (Kelley, Fujioka, Liang, Cooper, Jamieson and Desveaux 2020).

Digital implementation has been found to have positive impact on how quickly and effortlessly the work can be done. Almost a real time information sharing, and more opportunities have been seeing as an improvement due to digital implementation. Digital approach can lead to understating more about the process and gain more knowledge. Shared and received support has been to be valued in digital implementation process. Work quality has increased when digital aspect has hindered the previously manually handled tasks. Digitally improving the way of working has been found to increase work satisfaction. Archiving digitally will make retrieving and making adjustment more sufficient. (Thun, Bakås and Storholmen 2022; Parviainen, Kääriäinen, Tihinen and Teppola 2017.)

Digital implementation has its upsides but there are also downsides. It can positively effect on work effort by reducing it but when not functioning properly or incompatible communications between systems, it can increase the work effort. If implementations are happening in short time periods before individual has been properly trained and gained experience from the previous implementation, it also can lead to increased work effort and stress. (Kaihlanen, Laukka, Nadav, Närvänen, Saukkonen, Koivisto and Heponiemi 2023) Risks and benefits are shown in TABLE 3.

TABLE 3. Risks and benefits of implementation

Risks	Benefits
Legislation and policies	Quickens working, time management
Insufficient planning	Reduce work effort, more sufficient
Data safety and security	Wider and quick access to data
Interoperability, badly functioning systems, increased work effort	Shared effort and support
User related factors (phobias, trust)	Increases work satisfaction

5 PURPOSE, AIM AND RESEARCH QUESTIONS

The purpose of this thesis is to research the possibility to implement a paperless ECG to Niuvanniemi hospital NEMO-unit. In that way, ECGs would be handled and stored digitally and would be accessible from variety of locations throughout the hospital for doctors to evaluate the EGCs and for nurses to upload them. The aim of the thesis is to find out is possible at this state to begin the implementation or are the any barriers. The research data would be used to gather information for the future implementation and perhaps make the paperless ECG available to the entire hospital.

Research questions of the thesis:

1. What needs to be considered when carrying out the implementation of the digital ECG?
2. What are the barriers that will affect the implementation of the digital ECG?

6 RESEARCH METHODOLOGY

6.1 Qualitative research and research interview

Qualitative research aims to understand the phenomena that occurs during research from the perspective of target of the study, meaning you are interested in their perspective, opinion, thoughts, and their meaning, what the study target bring forth. Qualitative research is typically used to research a problem. In qualitative research, the research material is acquired by using interviews (single or group), documents or by observation and these are usually connected to each other. It is important to gather the experience from the study target and this might prove a challenge because the study target should be able to converse openly about the experiences related to the research. (Juuti and Puusa 2020, 9-13.) The interest to the subject arose from simple conversations and it was found that this would be a good topic to research and take as a thesis idea. The idea was confirmed from different individuals who are connected to NEMO-unit. In a short period, the idea was deemed worthy of researching. The research firstly began from getting knowledge about the topic of ECG and researching the use of digital ECG and it's use. Digital ECG can be seen to be a part of digitalisation and digitalisation was also researched.

Research interviews are most used for gathering study material. Research interviews are conversations with a goal that was set in advance. Researcher is the conversation enabler and the leader. In a conversation with another, the party affects one another. Research interview can be done from different perspectives and the interview can be executed in various ways. As a research material gathering method, an interview is quite flexible. Research interview is an alternative to research questionnaires. (Puusa 2020a, 99.) As research progressed it was shown that interviews were ideal methods to gather experience and opinions straight from an individual, so it was chosen as a method a gathering study material. Although the experience of conducting interviews were limited, after a thought period, it was perceived as the better method compared to questionnaires.

In research interview the participants are in direct interaction with each other and this creates the opportunity to aim research material gathering in the conversation. Non-verbal actions help understand the answers. (Hirsjärvi and Hurme 2022a, 39.) The advantage of research interviews is that the targeted interviewees have experience on the study phenomena or knowledge about the issue. Researcher guides the interview but not too much. If the interview is structed, then the research performs the guidance of the interview. (Puusa 2020a, 101-102) Research interviews are various types, and they differ from one another. These types are unstructured interview, semi-structured interview, theme interview, in-depth interview (Hirsjärvi and Hurme 2022b, 42)., reflexive interview and a group interview (Puusa 2020a, 109). The participants to the research interviews were thought to be individuals who are connected to the subject from different levels. It was thought that through the method interviews the experience would be gathered more effectively since participants are in a same room sharing the experience.

Structured and semi-structured interview are conducted with preset questions from the interviewer and the questions are based on theory. The questions are presented the same way, and they follow

the same construct. The difference between structured and semi-structured is that in structured interview the answers are pre-set as well. Theme interview is also considered to be semi-structured interview which is used when is presumed that interviewers have gone through and experienced certain process. Interview will follow beforehand chosen themes and questions associated to them. (Puusa 2020a, 106 – 110.) It was thought that with semi-structured interview with pre-set questions it would be easier to perform the interview since the experience of interviewing was limited. With pre-set questions it was easier to follow the interviewing path and minimize the possibility of confusion during the interview.

The interaction in an interview contains words and their meaning and interpretation. (Hirsjärvi and Hurme 2022c, 40). There are limitations in research interview. Trust is important in interviews and it's up to the interviewer to gain a trustworthy setting so the interviewee will feel comfortable to share his/her thoughts and opinions completely. Using a common language so persons who are attending the interview can understand each other. The interviewer should keep that in mind that his/her influence can alter the response and answers. Trial interpretation might occur if the question is not understood. (Puusa 2020a, 103 – 104.) Working in NEMO-unit and with other in a multi-professional work community, trust was gained with each other. It was thought that trust would also be present in the interviews, but it was important to maintain the role of a interviewer in these interview settings.

6.2 Data collection and target group

The data collection of this thesis was selected to be performed with interviews because of its flexibility and ability to gain experience on the topic from interviewees (Tuomi and Sarajärvi 2018a, 62-63.). It was thought that five interviews were enough for collecting data for this thesis. The interviews are planned to be performed as individual interviews. In a semi-structured interview advantage is that interviewer will get answers from interviewees based on their experience and thoughts. (Puusa 2020a, 105). The interviewing type was selected to be semi-structured. Interviews themed are about how to carry out the digital ECG implantation at Niuvanniemi hospital what barriers there might be. Interview questions are based on Theory Acceptance Model 3 (FIGURE 6) to understand the acceptance of implementing current ECG system into a paperless system.

Interviews were planned to be conducted in Niuvanniemi hospital. Interviews durations were planned to take 1 hour, and they are to be recorded and after that the recordings are transcribed carefully. When transcribing has been done, the recordings are deleted. Interview time was agreed with the interviewees in advance. The target group of the thesis are individuals who are connected to working with ECG, in the implementation process and the organizations legislation process.

6.3 Data analysis

The purpose of data analysis is to understand and describe the studying phenomena. The data analysis purpose is to create a whole from the data which will help to produce a describing interpretation and make conclusions about the study phenomena. First impressions about the data will come when collecting data and starting the transcribing process. Analysis starts with reading the transcribed data several times to create a whole understanding of the data. (Puusa 2020b, 143-147)

Transcribing material is also sometimes referred as coding. Non-research related findings need to be left aside either entirely or used them on a future research study. (Tuomi and Sarajärvi 2018b, 78.)

After gaining a preliminary picture of the research material, then it needs to be investigated in more detail by cut into pieces. Then the material will be simplified to help to delimit which will bring the essential data forth. Secondly the material will be grouped by putting similarities into same groups. Using theming will help put similarities to categories, in which after the category is named accordingly to the research. These categories will be added to create an upper category which is also named. All the possible upper categories are merged into the main category. (Puusa 2020b, 143-147) All the produced categories are merged to into one category that defines them all and these will help to answer the research questions (Tuomi and Sarajärvi 2018b, 85.).

The interviews were planned to be performed as individual interviews, but due to time scheduling conflicts it was better suited to perform the interviews as group interviews. Two grouped interviews were performed with total of five interviewees. The interviews were conducted in May and early June of 2024 in Niuvanniemi hospital. Interviews were conducted in Finnish. After each interview, the recordings were transcribed which led to the analysis of the material (APPEDIX 4). The data analyzation process began where original expressions were processed and simplified. The plain expressions were grouped together and formed subcategories which in turn were used to form upper categories. Main categories were created from upper categories (TABLE 4).

TABLE 4. Example of data analyzation

Original expression	Plain expression	Subcategory	Upper category	Main category
"Well, I have an experience that the device works well at best, but then copying the paper results with a copier either from the staff, the nursing staff or the secretary is tedious and the end result is probably not as usable as it is in that medical-scientific purpose. Why is the cardiac film	The device works Copying a paper output is tedious The end result is not usable	The current ECG method is not perceived to work Difficulty in paper printing The ECG printout is difficult to compare sooner or later	A paper-printed ECG is difficult	Utilization of digital ECG in nursing

taken in the first place"				

7 RESULTS

7.1 Current method of taking ECGs

Research results indicate that the current method of documenting ECGs is by printing ECG paper from the ECG machine and then copying in using a copier or in some cases send the printed paper to secretaries to print and document it into patient's records Results also bring forth that the paper document of the ECG is hand delivered to the right recipient inside the hospital. In some cases, there have been situations that the paper ECGs has not been placed properly into the patient's records or the paper ECG is still being reviewed. It would be difficult to find the ECG paper if it's being misplaced.

> *"copying a paper printout with a copier either from the staff, nursing staff or by the secretary is laborious"*
>
> *"if you want it for the doctor, then it needs get physically get it somehow"*
>
> *"if you try to look for it, it might remain in the doctor's use and it won't end up in the patient's papers, so sometimes it's challenging to find that old ECG"*
>
> *"Maybe it doesn't reach the people it should reach, and the ECG can't be found it if it's needed"*

After the ECG has been taken and if there is a need to cross reference it with a previously taken ECG, then it is shown that the paper is not necessarily high quality enough for cross referencing. Results also find that there is still functionality in paper-based ECG when you can write observations on the paper itself. It is thought useful with the current paper-based ECG that you can reviewed it on the paper if not able to review it on the ECG machines screen.

> *"after interpretation, if you later want to compare them, for example, the photocopy ed film is not of the same quality"*
>
> *"you can still write on it, if there's something like that, even if the subject has rubbed a lot or is trembling or something like that"*
>
> *"you can still see what the curve looks like on paper, if it passes by when it runs on the screen, then when it becomes the paper printout, you can still look at it a little longer"*

There are nurses who have not had experience from any other methods of taking ECGs, so they consider the current method of taking ECGs as functionally working. The current methods of taking ECGs usefulness are thought to be working since there are no alternatives method being used.

"I have no other experiences than this current ECG method, so this has been quite functional"

familiar and easy and I don't know any other method and that, well, usefulness, so yes, this has worked just fine until now, when there has been no other option"

Summary of the current method of taking ECGs are show in FIGURE 7.

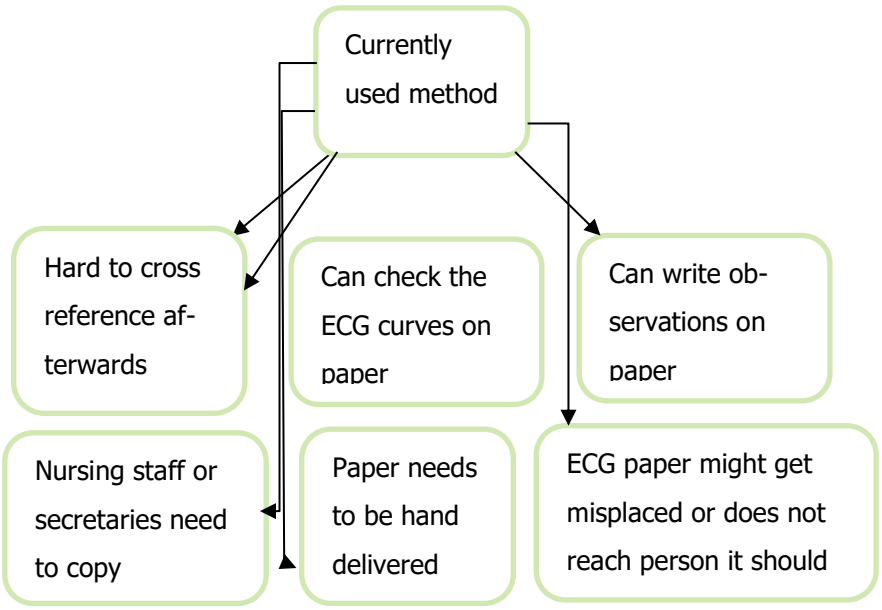

FIGURE 7. Summary of results of currently used method of taking ECG

7.2 ECG Machine, Digital readiness and Digital ECG

The ECG machines that are being used to take the ECGs are being thought of as functional for being mobile and easy to carry. Also, battery function is considered as a positive feature so there is no power cord issues, or the device need to be plugged when in use. The ECG machine is described to be able to produce data digitally, but the transferred location of the data is still unknown.

"the equipment itself is a mobile device, so it's good that it's transportable and light and doesn't need mains power immediately"

"the device produces a digital image, if necessary, but transferring them from the device to the image archive is unresolved"

Digital readiness is thought off being operational in some form, especially when the ECG machines have capability to produce ECG in digital format. Results indicate that digital readiness is thought of

being in poorly condition when taking it from the nurses' point of view. There have been constructions of networks and background systems in the hospital. That way digital readiness is functional. There is still need to research how the data will transfer and what kind of systems are needed to operate with data security in mind.

> *"The readiness exists in a certain way, but we have a device capable of producing it in digital form"*
>
> *"Bad, at least from the nurse's point of view"*
>
> *"built background systems and interfaces and then take into account that we will have different digitized material from different sources, those backgrounds are fine that way, but here we still have to find out, through which information flows to where and, and then what are those systems like down there and the fact that, this can then be done in a secure manner, that such things are taken into account"*

When considering the usefulness of digital ECG, accessibility was considered one of the key factors that is needed, so it would reach the required personnel. Thus, not relying on physical delivery and copying it by using copy machine. After taking ECG and sending it digitally, doctor can review it right after it has been sent or at the same time when taking it. Also, if needed to take another with different settings. Digital ECG would be able to produce patient security better when there are ECGs that can be cross reference, and they are being able to review remotely.

> *"At least I wish it could be sent somewhere where people could compare, them and everyone would see the same ECG"*
>
> *" That accessibility"*
>
> *"then if it shows something right away, or you can call the doctor about it, saying, hey, I sent this, so can you take a look or do you want some different connections or do you need to do something, so that it can be interpreted somehow"*
>
> *"patient safety would improve when there are more comparable, mutually comparable, previous documentaries, i.e. these cardiac films, available for viewing"*

Summary of the results of ECG machine, digital readiness and digital ECG are shown in FIGURE 8.

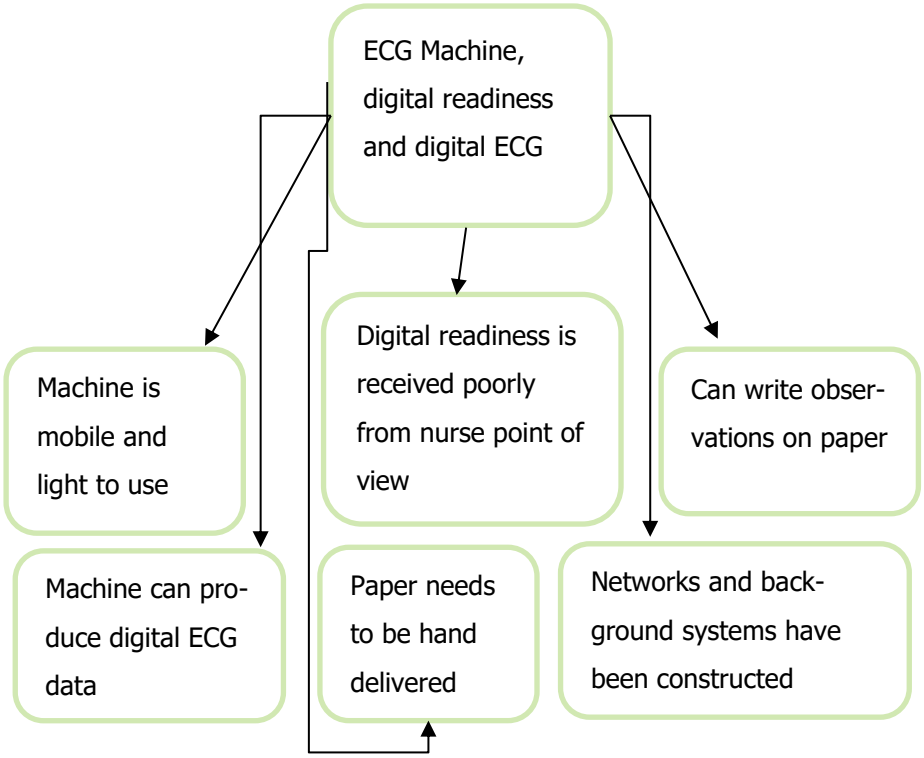

FIGURE 8. Summary of the results of ECG machine, digital readiness and digital ECG

7.3 Digital archive and formats

Digital ECG would bring the benefit of digitally archiving ECG data. In which it would ease the process of taking ECGs when comparing to the current method of taking ECGs. It is preferred that when digital archiving has been achieved than it would have an impact on the time that takes to take an ECG. Digital archive would remove the need to using a copy machine to copy ECG paper. It would bring more time for attending patients and less time with machines and copying machines. There might be possibility to transfer data between another healthcare provider to remotely ask from for consultation in case of a cardiac related situation. Digital archive would decrease the time that takes to get a consultation when the ECG is digitally available. There is still paper archiving which include patient records, but since joined in Kanta archive, some patient records are only digitally archived.

> *"I would only wish that the archiving would be digital and would consume less work time, preferably not at all, that the patient care and examination would be what would take up work time and what should be taken, and then that fiddling with machines and devices and copiers would be eliminated"*

> *"in the case of cardiac films, if the image material archive is such that it is able to use the information and pass it on to another organization in the event that there are cardiac events, then we can request a consultation from another specialist organization more easily."*

> *"In that paper archiving, we produce a lot of paper material, and new paper forms come to be archived quite frequently, but a lot has also already been transferred by joining Kanta-archive. Several reports are currently archived only in the Kanta archive, electronically"*

File formats came into question when considering transferring ECG data across platforms. There are variety of file formats available for ECG data which it could be converted. There where considerations that in what way does these ECG machines convert ECG data. It still unknown that if there is an option to choose the desired file format or is there a need for a separate viewing software which enables to ECG data to be processed. The ECG manufacturer's might have a designated format of their own.

> *"then what is the file format, what does the device produce, for example, does it require a separate viewer"*
>
> *"it's not a PDF document, it's some other specific device manufacturer's own file format"*

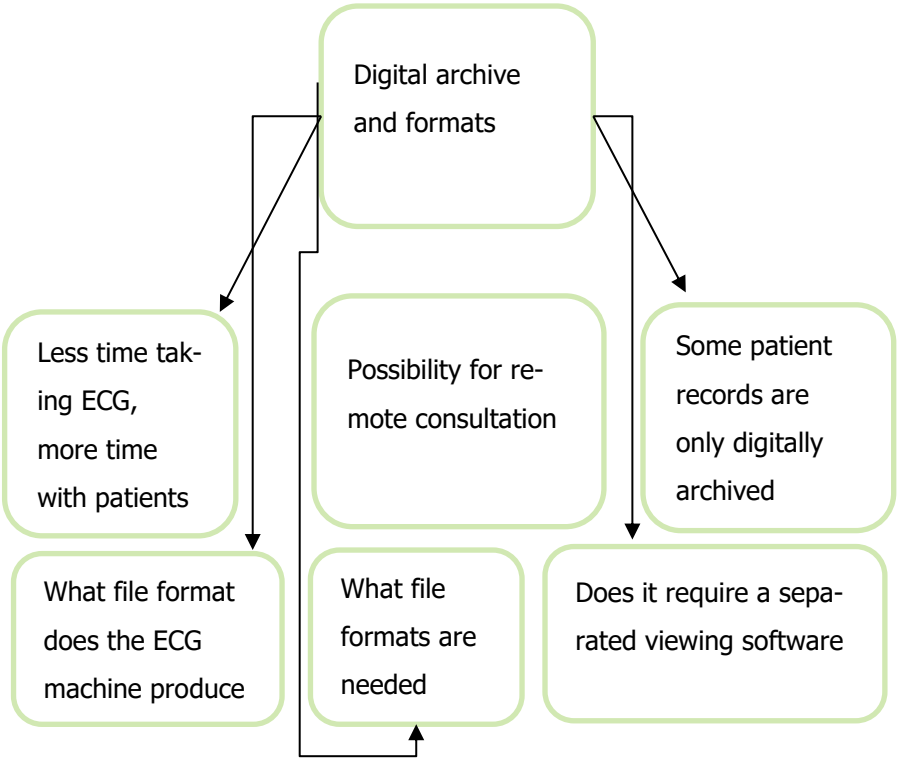

FIGURE 9. Summary of the results of digital archive and formats

7.4 Barriers

When considering what type of barriers there might be towards implementing digital ECG, research results indicate that financial situation and budgeting arose to be the most prominent barrier. The costs of the digital implementation rose as one possible barrier where cost of digital ECG exceeds the need. One method of gathering information about the possible costs is to gather information about the quantity of ECG take in the hospital. The average amount of controlled taken ECGs and how many are taken on-call. The information might be gathered from the main archive.

> *"financial situation at the moment, financial situation"*
>
> *" at least one obstacle can be the cost rising to an unreasonable level in relation to the needs of our organization, and then, in order to clarify the cost aspects, perhaps it would be good to map out as a*

> *preliminary what kind of volumes we actually have in the organization on an annual level in taking these cardiac films, how many cardiac films we take on average in a controlled and extra on-call basis, whether that possible information can be obtained from, for example, our archive, our own main archive"*

Finding a reasonable financial solution is important because lack of digital archiving has an impact. Now, all the ECG papers among other documentations are stored in a physical archive location which has a limited storing capacity. One step to finding a solution is to make project plan which will indicate what needs factors need resources which will indicate the cost but also the financial benefits should be stated.

> *"that we must be able to overcome these obstacles and get such a reasonable, if economical, solution at this time, because this affects quite a lot of things and one of them is archiving. We archive a lot of stuff on paper. We are running out of storage space. We should hopefully aim for this digitization at some point"*

> *"'n a way, make a small project plan, where all the resources need to be allocated financially and in terms of human resources, that of course the costs also determine what makes sense to implement. the financial benefit, of course, must also be considered here"*

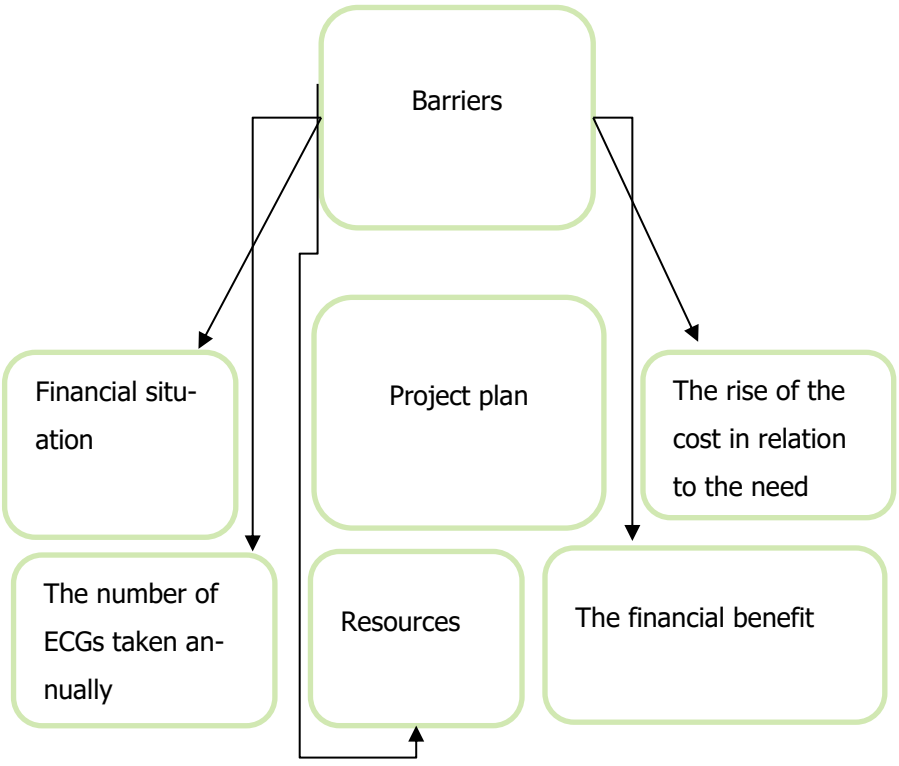

FIGURE 10. Summary of the results of barriers

8 CONCLUSION AND DISCUSSION

8.1 Reviewing the results

Purpose of this thesis was to research the possibility to implement a paperless ECG to Niuvanniemi hospital NEMO-unit. The aim of thesis was to find out it is possible at this state to begin the implementation or are there any barriers.

The first research question considered the needs when carrying out the implementation of the digital ECG. From technical aspect the participants considered the data, and patient security needs to be handled accordingly that the ECG data taken from the patient can be transferred from the machine to potential digital archiving software securely. Data security is one of the most important parts of implementation process (Marwaha, Landman, Brat, Dunn and Gordon 2022). There have been constructions of secure networks for example for laboratory data use, and background systems, but the actual digital archiving software is still lacking. The digital readiness in the hospital cab be understood to be at some level with these network and background system constructions and with the ECG machines that can send digital data. Among the participants, especially from the nurses' point of view, the digital readiness was received as being in a poor situation. Considering the current method of taking ECGs, participants considered to be old fashioned and needed to be upgraded. Perhaps informing more openly about any digital or technological procurements or constructions would change the understanding of digital readiness to more positive manner. In TAM-model user motivation are impacted with different aspects example and accordingly to the model digital readiness would be perceived as an image (FIGURE 6). Nurses today need to have adequate digital skill since digitalisation has become important tool in nursing. (Finnish Nurses Association 2021) Among the participants were few that had no knowledge of another method of taking ECG and thus taught that the current method of taking ECGs were sufficient. According to the TAM-model, experience has an impact towards user motivation and thus perceived usefulness (FIGURE 6). The need of digitally archiving ECG data was needed in the aspect of patient security and limited physical storing capacity.

In some cases, the paper-based ECG, which needs to be hand delivered, might get misplaced either during delivery or on the occasion not returning the to the patients records after reviewing it. In some cases, if patients ECG is missing and the condition of patient is serious, the outcome could prove dangerous to the patient (O'Conner 2018). Participants considered usefulness of paper-based ECG were the ability to take longer ECGs and make remarks if there were certain body movements happening during the taking of ECG. Participants were not aware if this would be possible in digital format. Research indicated that there were no results to this phenomenon. The accessibility of the ECG data was one of the needed functions in the digital ECG among the participants. After the ECG was taken and digitally transferred and archived, then the review could happen almost immediately when the ECG was ready for remote viewing. Cloud-based ECG would offer the benefit of having the opportunity to access ECG from anywhere over the hospital. (Hsieh and Hsu 2012) One aspect arose from the participants that the during the archiving process the ECG data will be looked and reviewed, not only archived. The ECG machines that are currently in use can transfer digital ECG data

but the lack of digital software where to send is lacking. Participants consider the current ECG machines functional for their mobile and lightweight functions. Participants were unaware about that ECGs should be archived to the Kanta archive no later than 1 October 2029. There were some considerations that there might have been some actions taken regarding this but was not entirely certain.

The use of digitally archiving is needed when participants considered what changes they need to the current method of taking ECGs. Archiving digitally would minimize or diminish entirely the misplacing of ECGs and would bring better opportunities to cross reference the current ECG with older ones. Digital archive was received as the better alternative to physical archive since there won't be the need for a physical archiving location to store the digital ECGs. Kanta services offer a way to sore medical images including ECG recordings in their Imaging Data Repository (Kanta Services 2024) There is physical archiving still present with different documents, example patient records that are stored. There has been a change in the archiving when joining the Kanta archive. There are some patient records that are only digitally archived. With digital archiving the need for copying with copy machines would seize and thus minimize the time to take ECG to some degree and bring more time to attend and spend time with patients.

When asking how digital implementation of digital ECG would impact their work and needed to be consider in the implementation. The participants thought they would need training to use of it and it would be beneficial towards not being time consuming process. Certain operating models need to be thought and considered if there would be a digital ECG implementation. Operating model consideration could include what software to use, the necessary data and patient data security aspects in mind, and if not producing paper-based ECG anymore then the process of maintaining the certainty that the digital ECG are viewed by a doctor and not just archived. Research found there to be remote viewing software for doctors to evaluate the digital ECG. In some cases, some software has evaluation tools embedded into them. (Marouf, Vukomanovic, Saranovac and Bozic 2017) Training aspect was thought to be too early to consider since there are no implementation plans of yet, but overall opinion was that there would be training involved. Digital formats were questioned during the research. It was found that there are numerous formats available and what formats do the current wECG machines produce and what formats is required to the Imaging Data Repository of Kanta services. Especially the later was unknown during the research. In Finland DICOM standard format has been in use. (Reponen, Keränen, Ruotanen, Tuovinen, Haverinen and Kangas 2022)

The second research question is about what barriers will affect the implementation of the digital ECG. Participants thought that financial situation of the hospital and budgeting would be the one of the barriers towards the implementation of digital ECG. There should be an enquiry of the possible costs that the implementation might need for example how many ECGs are taken within certain time periods and considering the financial benefits that the implementation might offer. Research indicate that financial situation could prove to be barrier in digital health implementations. (Desveaux, Soobiah, Bhatia and Shaw 2019) One of the benefits rose from the participants when considering digital versus physical archiving. Would digitally archiving produce more financial benefits. The firsts

steps would include making a project plan where these aspects are laid out and from that the procurement presentation is presented to the financial officer who then will consider it. A project plan with clearly stated cost effective results with evidence can be the starting point in the implementation process. (Kelley, Fujioka, Liang, Cooper, Jamieson and Desveaux 2020). The procurement needs to budget for the next several years and it might not be possible to acquire the needed budget during that year. Another barrier was working hours used in the preparation of the implementation and the time needed to train nursing staff on the use of the digital ECG.

It was thought that it is vital to be apart in the digitalisation in some ways consider to be an obligation to start the digitalisation process. During the research it was found that digital ECG is used not only globally but also nationally. Digital health has been predicted to bring more access to healthcare and to be next step in healthcare development. (Ronquillo, Meyers and Korvek 2023.) There are one form of data digitalisation happening in the form of EEGs which are stored to PACS after taking and the analysation is conducted in another facility by doctors specialized in neurophysiology.

8.2 Reliability and validity and ethics

Reliability in qualitative research can viewed from three standpoints: credibility, trustworthiness, and ethics. Credibility is shown, to the study target and peers, that the research material is gathered accordingly, and the analysing has been performed carefully which will affect their trust in the research. Trustworthiness is achieved when researcher can state that he/her has been able to use justified and proper approaches to achieve the research questions and carry out the research. Ethics is shown when researcher has maintained the ethnical principals throughout the research study. Research cannot pose any harm to the people who are the target group of the study. (Puusa and Juuti 2020, 167.)

The researching phenomena was known to the researcher. Knowledge of taking ECGs digitally were gathered when working to a previous employer several years prior working to the current employer. The digital aspect has been found fascinating, and an opportunity to learn more about it was provided during this research. It was felt that it was important to be apart in the digitalisation and bring more digital tools to the nursing staff. The quality of work would be enhanced by digitalisation. knowledge of taking ECGs and digital and technological points of view were held by the participants. Interviewers role was held by the researcher.

Research permit was sought from the chief nurse of Niuvanniemi hospital, and it was admitted to the researcher. The research participants were approach with an invite to the interviews. All participants accepted to be a part in the interview. Two set of interviews were conducted. The interviews had minor scheduling conflicts. First interview was almost 1 hour long, and the second interview lasted for 30 minutes. The interviews were taken inside the hospital, in private rooms to ensure the interviews were not interrupted and that interviewers would feel safe to participate in the recordings of interviews. The participants were informed about the recording of the interviews and after that they are transcribed. After the transcription the recordings were destroyed. It was stated that only the participants voice is gathered during this research and no other data, for example names or

ages, are not recorded. the idea of conducting the interviews were first thought to be a bit exciting since the interviewer has not conducted such interviews before. Also, the fact that interviewer was interviewing co-workers and the ability to maintain the role of an interviewer was also pondered.

Data analyzation was conducted using content analyzation technique. The interview recordings were transcribed first and read through to understand the material in a bigger picture. Transcribed materials were collected total of 14 pages. After that original expressions were changed to plain expressions in which were grouped together to form subcategories. These subcategories were used to form upper categories which in turn were used to form the main categories.

Probably conducting more interviews would have presented more valuable material and information for result reviewing and possibly conduct an interview with another hospital who has had digital ECG in use. Furthermore, to research how it was achieved and were there any barriers. For an alternative research method for this study was to conduct research on how many ECGs are taken annually, map the time that is needed to take ECG from start to finish.

8.3 Future research topics

During this research the implementation of the digital ECG has not been achieved but the possibilities and the usefulness has been researched. This research results might be able to use to further development of digital implementation in Niuvanniemi hospital or other facilities that have that are in similar situations. Research results might be able to be used to in the process of considering digital implementation for another form of medical imaging.

For future research topic arose to research the effects of digital ECG after it has been implemented. To study its effectiveness and usefulness when it has been implemented. Studying the differences between the former way of taking ECGs and now the digital ECG, to find out what has been considered useful and are there any barriers while the digital ECG is in use. This study could also include the research the usefulness of digital archiving.

The training for digital ECG might one aspect to research. There were some considerations about training for digital ECG during this research, but it was too early to state. When the implementation has been achieved and all the needed hardware and software factors are in working condition then training might be possible. To research on how the training was conducted and how was it received might bring useful information.

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APPENDIX 1: INTERVIEW STRUCTURE

Haastattelulomake

Tausta

1) Minkälaisia kokemuksia sinulla on nykyisestä EKG-menetelmästä?
2) Millä tavalla kuvailisit nykyistä EKG-menetelmää?
    a) Millä tavoin kuvailisit nykyisen EKG-menetelmän hyödyllisyyttä?
3) Millaisia haasteita on noussut esiin nykyisestä EKG-menetelmästä?
4) Minkälaisia muutoksia toivoisit nykyiseen EKG-menetelmään?
5) Miten tietoinen olet, että EKG tulee arkistoida Kantaan viimeistään 1.10.2029?
    a) Miten näet tämän vaikuttavan EKG-menetelmään?

Digitaalisen EKG:n käyttöönotto

6) Minkälaisena näet edustamasi organisaation digitaalisen valmiuden?
7) Minkälaisia hyötyjä näet digitaalisen EKG-menetelmän käyttöönotossa?
8) Millä tavoin digitaalisen EKG-menetelmän käyttöönotto vaikuttaisi työhösi?
9) Millaisia toimia edellytetään digitaalisen EKG-menetelmän käyttöönoton suorittamisessa?
10) Millä tavoin resurssointi tulee huomioida digitaalisen EKG-menetelmän käyttöönotossa?
11) Mitkä muut tahot näet tärkeiksi digitaalisen EKG-menetelmän käyttöönotossa?
12) Millä tavoin kouluttaminen digitaalisen EKG-menetelmään kannattaa toteuttaa?
13) Millaisia esteitä näet digitaalisen EKG:n käyttöönotossa?
    a) Millä tavoin mahdollisiin esteisiin voitaisiin puuttua?
14) Haluatko kertoa muuta aiheeseen liittyen?

APPENDIX 2: TRANSLATED INTERVIEW STRUCTURE

Interview form

Background

1) What kind of experiences do you have with the current ECG method?
2) How would you describe the current ECG method?
    a. In what ways would you describe the usefulness of the current ECG method?
3) What kind of challenges have emerged from the current ECG method?
4) What kind of changes would you like to the current ECG method?
5) How aware are you that the ECG must be archived in Kanta no later than 1 October 2029?
    a. How do you see this affecting the ECG method?

Implementation of digital ECG

6) How do you see the digital readiness of the organization you represent?
7) What kind of benefits do you see in introducing the digital ECG method?
8) In what ways would the introduction of the digital ECG method affect your work?
9) What kind of actions are required in implementing the digital ECG method?
10) In what ways should resourcing be considered when introducing the digital ECG method?
11) Which other parties do you see as important in introducing the digital ECG method?
12) How should training for the digital ECG method be carried out?
13) What kind of barriers do you see in the introduction of digital ECG?
    a. In what ways could possible barriers be addressed?
14) Do you want to tell us anything else about the topic

APPENDIX 3: ORIGINAL AND TRANSLATED QUOTES

”paperisen tulosteen kopioiminen kopiokoneella joko henkilökunnalta, hoitohenkilökunnalta tai sihteerin toimesta on työlästä”	*“copying a paper printout with a copier either from the staff, nursing staff or by the secretary is laborious”*
“jos sä haluat sen tietylle lääkärille, niin se pitää fyysisesti saada jollakin tavalla sinne”	*"if you want it for the doctor, then it needs get physically get it somehow”*
”jos sä yrität etsiä sitä, nii saattaa jäädä lääkärin käyttöön ja se ei päädy potilaan papereihin, niin joskus on haastava löytää sitä vanhaa EKG”	*”if you try to look for it, it might remain in the doctor's use and it won't end up in the patient's papers, so sometimes it's challenging to find that old ECG"*
”Ehkä just se ei tavoita niitä ihmisiä mitä sen pitäisi tavoittaa ja sitä ei löydä sitä EKG sitten, jos tarvitsee”	*”Maybe it just doesn't reach the people it should reach, and the EKG can't find it if it needs it"*
”tulkinnan jälkeen, jos halutaan myöhemmin verrata vaikka keskenään niitä, niin se valokopioitu filmi ei ole yhtä laadukas”	*“after interpretation, if you later want to compare them, for example, the photocopied film is not of the same quality"*
”siihen pystyy vielä kirjoittamaan, jos on jotakin semmoisia, että vaikka tutkittava on hieronut paljon tai on vapinaa tai tämmöisiä poikkeavia asioita”	*"you can still write on it, if there's something like that, even if the subject has rubbed a lot or is trembling or something like that”*
”tässähän pystyy tietysti siinä paperilla vielä näkemään sen minkä näköinen on se käyrä, jos se menee ohi siinä, kun se juoksee siinä kuvaruudulla, niin siitä kun tulee se paperituloste, niin siinä voi vielä tarkastella vähän pidempään”	*”you can still see what the curve looks like on paper, if it passes by when it runs on the screen, then when it becomes the paper printout, you can still look at it a little longer”*
“Minulla ei ole muita kokemuksia kuin tämä nykyinen EKG menetelmä, niin tämä on ollut ihan toimiva”	*“I have no other experiences than this current ECG method, so this has been quite functional"*
”tuttu ja helppo ja en muuta menetelmää tiedäkään ja tuota, no hyödyllisyyttä, niin kyllähän tämä nyt tässä tähän asti on toiminut ihan ok, kun ei ole ollut mitään muuta vaihtoehtoa”	*“familiar and easy and I don't know any other method and that, well, usefulness, so yes, this has worked just fine until now, when there has been no other option"*
“itse laitteisto on semmoinen mobiili, niin sehän on hyvä, että se on kuljetettavissa ja kevyt ja ei tarvitse verkkovirtaa välittömästi”	*“the equipment itself is a mobile device, so it's good that it's transportable and light and doesn't need mains power immediately"*

”laite tuottaa tarvittaessa sen digitaalisen, mutta ne siirtyminen laitteelta sinne kuva-arkistoon on ratkaisematta”	*"the device produces a digital image, if necessary, but transferring them from the device to the image archive is unresolved"*
”Valmius on tietyllä lailla olemassa, että meillä on kuitenkin laite mikä kykenee tuottamaan sen digitaalisessa muodossa”	*"The readiness exists in a certain way, but we have a device capable of producing it in digital form"*
”Huono, Ainakin hoitajan näkökulmasta”	*"Bad, at least from the nurse's point of view"*
”rakennettu taustajärjestelmiä ja rajapintoja ja huomioitu sitten, että meillä tulee erilaista digitalisoitavaa ainestoa eri lähteistä, että periaatteessa ne taustat ovat sillä tavalla kunnossa, mutta tässä pitää nyt vielä selvitellä, että mitä kautta tieto virtaa mihinkin ja, ja minkälaiset on sitten ne järjestelmät siellä alla ja se että, tätä voidaan tehdä sitten tietoturvallisesti, että semmoiset huomioon”	*"built background systems and interfaces and then take into account that we will have different digitized material from different sources, those backgrounds are fine that way, but here we still have to find out, through which information flows to where and, and then what are those systems like down there and the fact that, this can then be done in a secure manner, that such things are taken into account”*
”Ainakin toivoisin, et se vois lähettää jonnekin missä ihmiset vois vertailla niitä ja kaikki näkisi sen saman EKG:n”	*”*Atleast I wish it could be sent somewhere where people could compare, them and everyone would see the same ECG"
"Se tavoitettavuus”	*”That accessibility"*
"sitten jos siinä näkyy, vaikka saman tien jotakin tai sitten siitä voi soittaa lääkärille, että hei mä lähetin tämän, nii voitko katsoa tai haluatko jotain erilaisia kytkentöjä tai pitääkö tehdä jotakin, että sitä voi tulkinta jotenkin”	*”then if it shows something right away, or you can call the doctor about it, saying, hey, I sent this, so can you take a look or do you want some different connections or do you need to do something, so that it can be interpreted somehow”*
”potilasturvallisuus paranisi, kun on enemmän vertailukelpoisia, keskenään vertailukelpoisia, aiempia dokumentteja eli näitä sydänfilmejä katseltavissa”	*”patient safety would improve when there are more comparable, mutually comparable, previous documentaries, i.e. these cardiac films, available for viewing"*
”No, oikeastaan toivoisin ainoastaan sitä, että se arkistoituminen olisi digitaalinen ja kuluttaisi vähemmän mielellään ei lainkaan työaikaa, että se potilaan hoitaminen ja tutkiminen olisi se mikä veisi työaikaa ja minkä kuuluukin viedä ja sitten se koneiden ja laitteiden ja kopiokoneiden kanssa kikkaileminen jäisi pois”	*"I would only wish that the archiving would be digital and would consume less work time, preferably not at all, that the patient care and examination would be what would take up work time and what should be taken, and then that fiddling with machines and devices and copiers would be eliminated"*

sydäfilmien osalta, jos se kuva-aineisto arkisto semmoinen, mitä pystyy käyttämään tietoa, välittämään sitä kautta toiseen organisaatioon tämmöisessä tapauksessa, että on jotain sydänperäisiä tapahtumia, niin pystytään niihin pyytämään konsultaatiota jouhevammin toiselta asiantuntijaorganisaatiolta" "	*"in the case of cardiac films, if the image material archive is such that it is able to use the information and pass it on to another organization in the event that there are cardiac events, then we can request a consultation from another specialist organization more easily."*
*"meillä tuossa paperisessa arkistoinnissa tuotetaan paljon paperista materiaalia ja tulee uusia paperisia lomakkeita aika tiheästikin arkistoitavaksi, mutta paljon on myös jo siirtynytkin Kanta-arkistoon liittymisen myötä. Useat kertomukset arkistoidaan tällä hetkellä ainoastaan Kanta-arkistoon, sähköisesti"" *	*"In that paper archiving, we produce a lot of paper material, and new paper forms come to be archived quite frequently, but a lot has also already been transferred by joining Kanta-archive. Several reports are currently archived only in the Kanta archive, electronically"*
"sitten minkälainen se tiedostoformaatti on, minkä se laite esimerkiksi tuottaa, että vaatiiko se sitten jonkun katselimen vielä erikseen"	*"then what is the file format, what does the device produce, for example, does it require a separate viewer"*
ei olekaan mikään PDF-dokumentti vaan se on joku muu spesifi laitevalmistajan oma tiedostomuoto"	*"it's not a PDF document, it's some other specific device manufacturer's own file format"*
*ainakin yksi este voi olla se kustannusten nouseminen meidän organisaation tarpeisiin nähden kohtuuttomaksi ja sitten vielä kustannusnäkökulmien selvittämisessä olisi ehkä hyvä tehdä esivalmisteluna kartoittaa sitä että minkälaiset volyymit meillä tosiaan organisaatiossa vuositasolla on näissä sydänfilmien ottamisessa, että paljonko me keskimäärin otetaan kontrolloidusti ja ylimääräisesti päivystyksellisesti sydänfilmejä, onko sitä mahdollista tietoa saada vaikka arkistostamme, omasta päätearkistosta" *	*"at least one obstacle can be the cost rising to an unreasonable level in relation to the needs of our organization, and then, in order to clarify the cost aspects, perhaps it would be good to map out as a preliminary what kind of volumes we actually have in the organization on an annual level in taking these cardiac films, how many cardiac films we take on average in a controlled and extra on-call basis, whether that possible information can be obtained from, for example, our archive, our own main archive"*
"että meidän pitää nämä esteet pystyä kyllä voittamaan ja saada tässä aikaan semmoinen järkevä, joskin taloudellinen ratkaisu, koska tämä vaikuttaa aika moneen asiaan ja yksi mihin tämä vaikuttaa on sitten arkistointi. Meillä arkistoidaan paperilla valtavasti tavaraa. Meiltä	*"that we must be able to overcome these obstacles and get such a reasonable, if economical, solution at this time, because this affects quite a lot of things and one of them is archiving. We archive a lot of stuff on paper. We are*

loppuu arkistointitila. Meidän pitää tähdätä toivottavasti tähän digitalisaatioon jossain vaiheessa”	*running out of storage space. We should hopefully aim for this digitization at some point"*
"“tavallaan tehdä pieni projektisuunnitelma, että mihin kaikkeen tässä pitää resursoida taloudellisesti ja henkilöstöresurssien suhteen, että toki aina kustannukset määrittelevät myös sitä, että mikä on järkevää toteuttaa. se taloudellinen hyöty tietenkin tässä pitää myös ottaa huomioon”	*"in a way, make a small project plan, where all the resources need to be allocated financially and in terms of human resources, that of course the costs also determine what makes sense to implement. the financial benefit, of course, must also be considered here”*

APPENDIX 4: EXAMPLE OF DATA ANALYZATION

Alkuperäinen ilmaisu	Pelkistetty ilmaisu	Alaluokka	Yläluokka	Pääluokka
”No, mulla on semmonen kokemus, että laite toimii parhaimmillaan hyvin, mutta sitten se paperisen tulosteen kopioiminen kopiokoneella joko henkilökunnalta, hoitohenkilökunnalta tai sihteerin toimesta on työlästä ja lopputulos ei varmaan oo sillä lailla niin kuin hyvin hyödynnettävissä niin ku siinä lääketieteellisessä tarkoituksessa. Mitä varten se sydänfilmi alun perin otetaan”	Laite toimii Paperisen tulosteen kopiointi on työlästä Lopputulos ei ole hyödynnettävissä	Nykyinen EKG-menetelmä ei koeta toimivaksi Paperitulosteessa vaikeus EKG-tuloste myöhemmin hankala verrata	Paperitulosteinen EKG hankala	Digitaalisen EKG:n hyödyntäminen hoitotyössä
” Valmius on tietyllä lailla olemassa, että meillä on kuitenkin laite mikä kykenee tuottamaan sen digitaalisessa muodossa ja meillä on digitaalista kuva-aineistoo tallentavaa järjestelmä olemassa, että sinällään tämmöset digitaaliset valmiudet meillä on olemassa jo täällä, mutta näiltä osin, tietyltä osin mukaan lukien	Digitaalinen valmius on olemassa EKG-laitteessa mahdollista tallentaa digitaalisesti Digitaalista kuva-aineisto järjestelmä on olemassa Digitaalista toteutusta ei ole vielä	EKG-laitteessa digitaalinen tallennus mahdollisuus Digitaalinen kuva-aineisto järjestelmä	EKG-laite mahdollistaa digitaalisen kuvan	Digitaalinen kuvan käsittelyohjelma

tämä sydänfilmi, niin ei ole vielä toteutusta”				
” Oikeestaan toivoisin ainoastaan sitä, että se arkistoituminen olis digitaalinen ja kuluttas vähemmän mielellään työaikaa, että se potilaan hoitaminen ja tutkiminen ois se mikä veis työaikaa, laitteiden ja kopiokoneiden kanssa kikkaileminen jäis pois”	Digitaalinen arkistoituminen Pienempi työajan käyttö laitteiden ja tulostaminen kanssa Enemmän aikaa potilastyöhön	Digitaalinen arkistointi Työaikaa potilastyöhön	Tarve digitaaliselle EKG:lle	Digitaalinen arkistointi

APPENDIX 5: TRANSLATED EXAMPLE OF DATA ANALYZATION

Original expression	Plain expression	Subcategories	Uppercategories	Main category
"Well, I have an experience that the device works well at best, but then copying the paper results with a copier either from the staff, the nursing staff or the secretary is tedious and the end result is probably not as usable as it is in that medical-scientific purpose. Why is the cardiac film taken in the first place"	The device works Copying a paper output is tedious The end result is not usable	The current ECG method is not perceived to work Difficulty in paper printing The ECG printout is difficult to compare sooner or later	A paper-printed ECG is difficult	Utilization of digital ECG in nursing
"The readiness exists in a certain way, that we nevertheless have a device that is capable of producing it in digital form and we have a system that stores digital image material, that in itself we already have these digital capabilities here, but in these parts, in a certain part including this heart film, then there is no implementation yet"	Digital readiness exists It is possible to record digitally in the ECG device A digital image material system exists There is no digital implementation yet	Digital recording option in the EKG device Digital image material system	The ECG device enables a digital image	Digital image processing program

"Actually, I would only wish that the archiving was digital and would consume less working time, that the patient care and examination would be what took up working time, that fiddling with equipment and copiers would be eliminated"	Digital archiving Less working time with equipment and printing More time for patient work	Digital archiving Working time for patient work	The need for a digital ECG	Digital archiving