Satakunnan ammattikorkeakoulu
Satakunta University of Applied Sciences

JENNI MYLLYLÄ

Artificial Intelligence Applications in Finnish Healthcare

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ABSTRACT

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This study scanned and analyzed the usage of artificial intelligence in the field of Finnish healthcare. The purpose of this study was to map out the different artificial intelligence applications and systems, that are currently in the use of healthcare in Finland. More specifically what kind of AI applications there are, for what and by whom are they used and what is the amount of the applications. The aim of this study was to create an overall picture of the situation at the moment in order to increase understanding and knowledge of how AI is used in healthcare and how the field can benefit from the use of AI.

This study was conducted as an integrative review by using mostly qualitative methods with a sideline of quantitative approach. The results were collected during the year 2022. The study follows the Knafl and Whittemore's (2005) five stages of integrative review; problem identification, literature research, data evaluation, data analysis and presentation. The study was done mostly by searching through the internet with Google word searches (artificial intelligence/AI, healthcare, Finland), examining the companies and service providers web pages and interviewing people who work in the health technology field.

As a result 84 applications were found. The applications were divided to different groups; chatbots and virtual assistants (21), applications designed to assist the professionals (24), applications for monitoring and surveilling (20), applications for screening in the areas of radiology and pathology (14) and robotics (3). Then these groups were compared based on the ways in which the applications were used as well as their features. Most of the applications were utilized by professionals. In these applications AI is used for assisting the professionals, for monitoring patients and for screening purposes. Especially in the monitoring and screening applications, AI is used for analyzing the results. Applications designed for patients were mostly chatbots and virtual assistants. AI has already been implemented to the use of healthcare in multiple ways and its usage is likely to increase as the technologies develop further. In the future AI has the potential to make healthcare professionals work more effective and efficient.

Keywords: Artificial intelligence, AI, application, healthcare, Finland

CONTENTS

1 INTRODUCTION

With the wave of rapidly spreading and developing digitalization and various technologies, artificial intelligence is taking its place in our society and the healthcare sector. Currently, healthcare is suffering from a lack of resources, a worsening labor shortage and an accelerating need for healthcare services, largely due to the increase in the number of elderly people suffering from various health problems and also the Covid-19 pandemic. In these challenging times, there is hope that developing digital services and AI applications will help the healthcare field. (Neittaanmäki & Vähäkainu, 2018.)

Although the AI technology is developing and expanding through different fields, not much research has been done on the applications of artificial intelligence used in healthcare in Finland. While there is a lot of material on the subject of AI in healthcare over the world, the information about the usage of AI and these AI applications in Finland is very scattered and unstudied.

The purpose of this study was to map out the different artificial intelligence applications and systems in the use of healthcare in Finland at the moment, more specifically the types and amount of AI applications and their purpose of use. The aim of this study was to create an overall picture of the situation at the moment, in order to increase understanding and knowledge of how AI is used in healthcare and how it can benefit from the use of AI. The benefits of mapping and gathering the AI applications to one place are increasing the understanding and discovering the use, and the possibilities of AI in the healthcare sector. Understanding how and where AI is and can be used will drive the growth of wider usage and support the implementation of these technologies. Increasing knowledge about the benefits of artificial intelligence adds value to research results. This thesis was partly sponsored by the AI Forum Consortium project funded by the Ministry of Education.

2 ARTIFICIAL INTELLIGENCE IN HEALTHCARE

In the 20th century, technological innovations led to an unprecedented spread of automation, and the development has only accelerated in the 21st century. Artificial intelligence (AI) is part of this revolution. AI is a relatively old concept, and its development leads back to the early days of information technology (IT). The development of intelligent machines is considered to have actually started in the 1950s. In the following decades, the development of artificial intelligence progressed and had its ups and downs. (Neittaanmäki & Vähäkainu, 2018.)

In the 1970s and 1980s, development focused on rule-based systems and from the 1980s machine learning has been flourishing. At the beginning of the 2000s, there was a return to data-based artificial intelligence. Deep learning came along in the 2010s. Today, machine learning forms the basis for the latest artificial intelligence applications in various fields, including healthcare. (Neittaanmäki & Vähäkainu, 2018; Morgenstern et al., 2021.) The timeline of the development of AI can be seen in Figure 1.

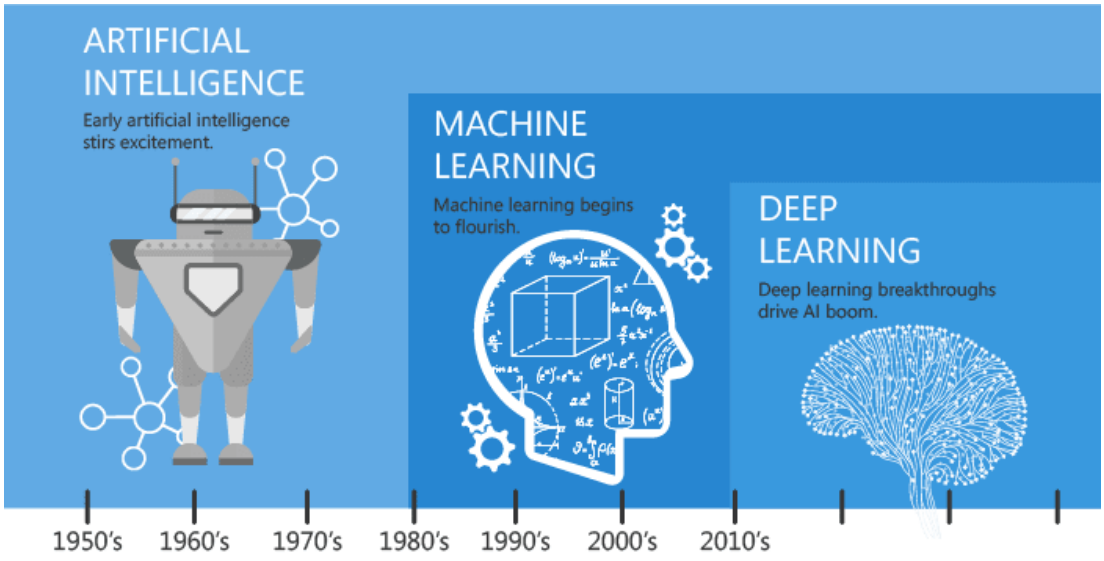


Figure 1. Timeline of the development of artificial intelligence. (Huynh, 2022.)

2.1 Artificial intelligence

Artificial intelligence often does invisible work in our everyday life, powering search engines, making product recommendations, and being behind speech recognition systems as well as having a more visible role in applications like Apple's Siri, Amazon's Alexa, IBM Watson, and self-driving vehicles. Artificial intelligence will be a part of every field of business and in every part of the world in the future. (IBM Cloud Education, 2020.)

The general term artificial intelligence describes various techniques used to make computers behave in some intelligent way. There is no agreed definition for AI, but in general, the ability to perform tasks without supervision and the ability to learn and to improve performance are key components of AI. Many kinds of explanations and definitions can be found for artificial intelligence, for example, Borana (2016) defines it as a way to help solve complex problems when talking about computers or machines. AI combines physiological intelligence and information technology. Intelligence can be defined as the ability to think by creating memory, identifying, and understanding patterns, learning from experience, and making choices that can adapt to chance. Artificial intelligence can make machines behave like humans.

IBM Cloud Education (2020) writes that "artificial intelligence leverages computers and machines to mimic the problem-solving and decision-making capabilities of the human mind". One definition of AI is advanced analytics combined with automation. Many AI applications, like intelligent interactive user interfaces, are automation of operations based on real-time analytics. And in the end, all applied artificial intelligence is based on analytics, whether it is image, sound, text, or any other data in question. (Randén, 2017.)

Artificial intelligence is a broad, upper concept term, designed to make computers imitate people-like thinking and simulate the things people do. Ultimately AI will generally solve problems better and faster than people. AI

can perform creative tasks such as planning, moving, speaking, recognizing objects and sounds, and performing social and business transactions. (Buczkowski, 2017.) Artificial intelligence enables the processing of large amounts of stored data from data repositories in an intelligent way and the conversion of relevant information into functional tools. (Neittaanmäki & Vähäkainu, 2018.) Artificial intelligence has applications in almost all human activities. There are many different categories of using AI; robotics, vision systems, natural language processing (NLP), neural networks (NN), learning systems, expert systems, and decision support systems (DSS). (Borana, 2016.)

Artificial intelligence is categorized on three levels based on the capacity to mimic human characteristics:

- Artificial narrow intelligence (ANI)- Narrow range of abilities.
- Artificial general intelligence (AGI)- On par with human capabilities.
- Artificial superintelligence (ASI)- More capable than a human.

Applied AI, otherwise known as weak or narrow AI is able to produce a solution for a problem that is precisely defined. An applied artificial intelligence application can, for example, convert speech into text, recognize characters, and interpret the desired action from the text. The current AI applications are still far from the level of General AI, and narrow AI drives the most AI applications that surround us today. Artificial General Intelligence or strong AI refers to the ability of a machine to comprehensively imitate human intelligence. Both artificial general intelligence and artificial super intelligence are theoretical forms of AI, where the machine would have equal intelligence and capability to humans, and superintelligence would surpass it. In both cases, it would have a self-aware consciousness with the ability to solve problems, learn and plan for the future. (IBM Cloud Education, 2020; Randén, 2017.) The different areas of AI which are talked about in the next chapters can be seen in Figure 2.

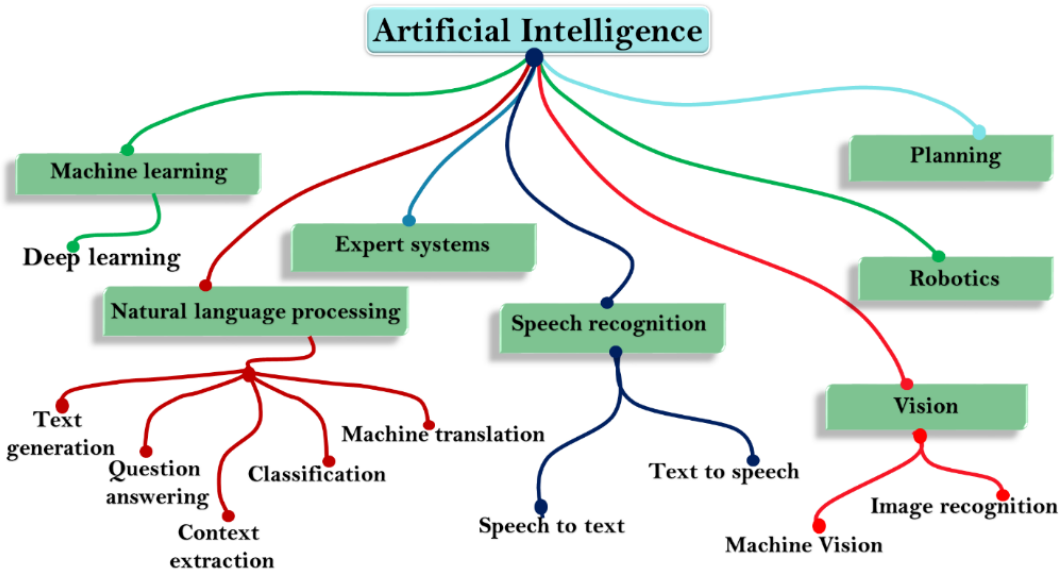


Figure 2. Different areas of AI. (Javapoint, n.d.)

2.1.1 Machine Learning, Deep Learning and Neural Networks

Machine learning (ML) and deep learning (DL) are sub-fields of artificial intelligence, and deep learning is a sub-field of machine learning, as can be seen from Figure 2. Machine learning means the field of data processing, in which the algorithms learn to recognize patterns without being programmed separately. This means that ML allows computer systems to automatically learn from experience. ML algorithms learn from large amounts of sample data and the data is mostly structured. Machine learning requires more ongoing human input to function and get results. (Decher, 2021; Kavlakoglu, 2020.)

Deep learning is a subset of machine learning in which artificial neural networks adapt and learn from vast amounts of data. Deep learning is like the next evolutionary stage of machine learning and after its set up, it needs minimal human intervention. DL methods can be used to structure algorithms into multiple layers to create an artificial neural network (NN). The network

learns by itself and can make decisions on its own. NN works exceptionally well when working with large amounts of data, so-called "big data". Deep learning can use unstructured data and it doesn't need predefined attributes. DL is used in medical diagnostics, search engines, recognition, identifying and processing of images, texts, speech, and in autonomous vehicles to recognize objects. (Decher, 2021; Kavlakoglu, 2020.) Figure 3. presents different technologies which are using AI.

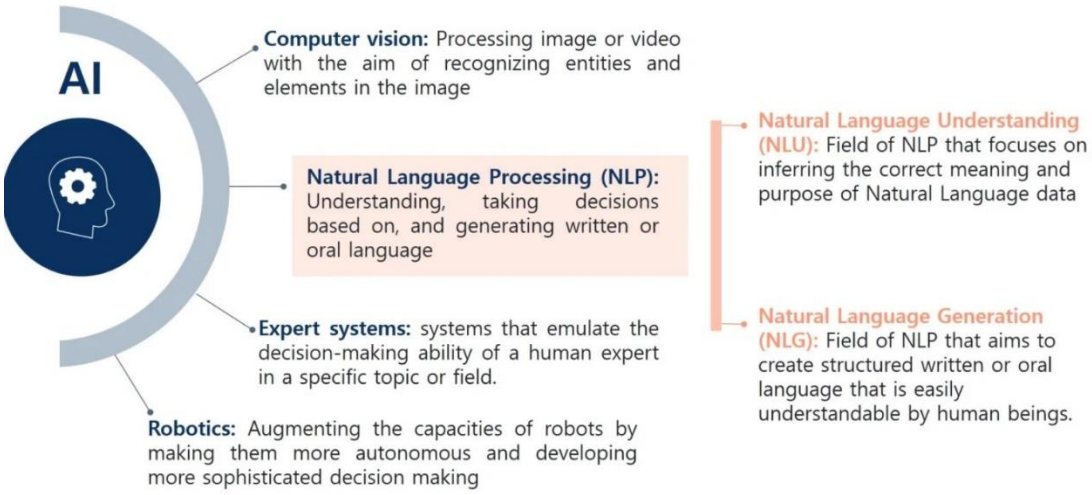


Figure 3. Technologies using AI. (Alsina et al., 2022.)

2.1.2 Natural Language Processing

Natural language processing (NLP), also known as text mining, is a form of artificial intelligence. NLP can plow through big masses of information, and it allows automated processing and analysis of free unstructured text. It turns free text into structural text, like a summarization or translation, making it more usable and accessible for the end users. NLP can process both text and speech. A few good examples of NLP usage are chatbots, speech to text conversion and Google search. (Allot et al., 2021; Ponraj, 2020.)

In the healthcare context, through the usage of NLP there is a way to determine which words mean symptoms, diseases, or signs and then those entities can be linked to known ontologies or terminologies to build a set of rich, potentially predictive features. After this, the features can be fed into other machine learning or clustering channels with standard structured data to find potential patients who are at-risk. This is a powerful combination for the machine learning technologies. (Allot et al., 2021; Siwicki, 2022a.)

Natural language understanding NLU and Natural language generation NLG both are fields of Natural language processing NLP, as Figure 3 shows. Natural language understanding (NLU) focuses on interpreting the correct meaning and purpose from the data. Natural language generation (NLG) means generating the response text, it is used in chatbot software. One sub-concept of chatbots is a conversational artificial intelligence. Conversational artificial intelligence is used between a human and a machine by using text or speech interaction interface. Artificial intelligence has been taught to understand the language used by humans. AI is often trained with data created from the conversations between humans. Artificial intelligence can learn an unlimited number of new things, but in order to learn, it requires data to both teach and test what has been learned. (Accenture, 2020.)

The operating principle of conversational artificial intelligence is to classify the user's incoming message and it is used mainly in chatbots. In this context, artificial intelligence is defined on whether the chatbot can answer the users' message in a meaningful way. The challenge in this situation is that there are no repeated questions in real life conversations, people ask the same questions in different ways. The conversational AI is taught by giving example sentences or utterance about what is expected from certain messages. In this case a machine learning system is used for the AI to learn from the examples so that every word or sentence structure doesn't need to be taught separately. Another way to utilize AI in chatbot software is a rule-based system, where it is described in advance what words may or may not be used in the messages for a certain intention. It uses a predefined dialogue frame. (Kwork Innovaatiot, 2020.)

The key challenge now for the conversational AI chatbots is that they are still in very early stages in Finnish social and health care. They can mostly just provide service guidance, give information, and direct customers to other services. The solutions are mainly customer service virtual assistants, which are used for general advice and guidance to customers and patients. Development has so far been organization-oriented, isolated, and point-like. Hyteairo has established the Sotebotti network to develop conversational social security artificial intelligence in Finland. (Kwork Innovaatiot, 2020.)

2.1.3 Robotics and Computer vision

Robotics combines machines, engineering, science, technology, and artificial intelligence. Most robotics are hardware that mimic human functions. AI increases the capabilities of robots, makes them more autonomous and develops their decision making. Robots can help humans with work that is dangerous or difficult for human to do, like underwater exploration, research in the Antarctic or handling of dangerous medical substances. Robots with AI are used for example in surgery, transportation, and cleaning. (Alsina et al., 2022; Ponraj, 2020.) Robotics in healthcare can be categorized in medical robots (surgical robots and diagnostics systems), healthcare service robots (medication delivery, cleaning, telepresence, remote monitoring, transportation of specimens, food etc.) and care robots (companion robots, personal assistants, rehabilitation, exoskeletons, and prosthetics.) (Business Finland, 2020.)

Computer vision is a field of AI that enables computer programs to imitate a vision of a human. Computer vision takes advantage of deep learning models to process images or videos with the aim to recognize elements in the image. It can be used for example for different kinds of robots or self-driving cars to

detect and track objects, to classify and retrieve images. (Alsina et al., 2022; Ponraj, 2020.)

2.1.4 Expert Systems and Decision Support Systems

An information system does the processing of data to create information. A decision support system is an automated system that provides data and information to support a decision maker in the process of decision-making. An expert system actually uses the data and information to make a decision. (Nelson, 2018.)

Expert systems imitate human decision-making abilities. These systems use AI to learn, analyze, reason, remember and plan. There are many different forms of decision support systems (DDS), it can be used for example to give advice on investing in the stock market or give show recommendations in an online streaming service. In the healthcare sector radiologists can use clinical decision support systems to help with cancer detection from scan images or physicians can use DSS to manage health information for preventive care and diagnosing illnesses. In a bigger picture DSS can be used to improve overall performance of the healthcare companies, reduce costs and better the patient outcomes. (Lee, 2021.)

Human capabilities can be extended with the use of AI tools, for example, finding and analyzing relevant information from an extremely large data set or creating solutions from probabilities or rulesets. Intelligent decision support systems can be used to learn and understand from experience, understand unclear or conflicting messages, react quickly and successfully to a new and complex situation, and use reasoning to solve problems. (Phillips-Wren, 2012.)

2.2 Artificial intelligence in healthcare

Artificial intelligence has been used in many areas over the decades, perhaps the best known are defense and space research. There has also been an attempt to utilize artificial intelligence in medicine for a long time, and the first ones were rule-based systems utilizing AI, built using diagnostic algorithms that were based on human experience. Nowadays the field of artificial intelligence in healthcare is used for example in diagnosis, in making treatment recommendations and in surgery. (Vähäkainu & Neittaanmäki, 2018.) According to Rodriguez (2016), artificial intelligence in healthcare means utilizing data processing as an intelligent tool to aid professionals in clinical evaluation and decision making.

In their study Väänänen et al. (2020) are writing about the main areas of AI-based healthcare are clinical decision making, healthcare interventions, automatic care or healthcare process recommendations, patient administration, and patient monitoring. They are naming AI technologies that are commonly used in the healthcare sector, such as robot-assisted surgery, virtual assistants for nursing and consultation, assistant for administration and workflow, fraud detection, dosage error reduction, connected machines, clinical trial participation, preliminary diagnosis, image diagnosis, cybersecurity, medication management, health monitoring, and drug creation. These AI technologies are using natural language processing, neural networks and deep learning, rule-based expert systems, computer vision, robotics, and physical robots. (Väänänen et al. 2020.)

According to He et al. (2019) the general aim of using AI in medicine is to use the algorithms to reveal useful information from the healthcare data and to assist the professionals in clinical decision making. It is possible for the AI technologies to perform a wide range of functions like assisting in diagnostics, selecting treatment predicting risks, facilitating disease stratification, reducing medical errors, and improving productivity. The roles of AI applications in

healthcare are presented in Figure 4. Some of these functions are already being used in healthcare around the world, and some are being developed for the future. Some of the functions relate to disease prevention and health promotion, such as population health management, and some are used for medical diagnostics and treatment of diseases.

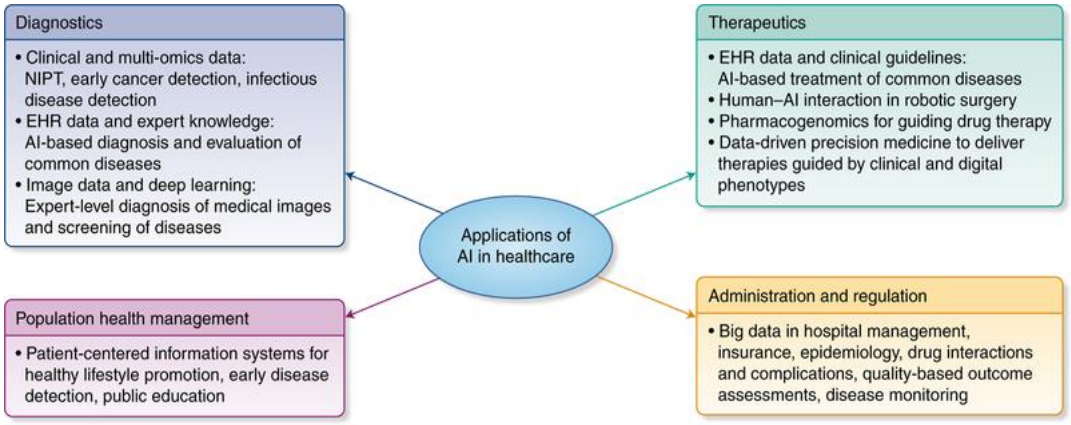


Figure 4. Roles of AI-based technologies in healthcare now and in the future. (He et al., 2019.)

There is a huge possibility in saving lives and managing the continuously increasing healthcare costs with properly used artificial intelligence. As AI will continue to evolve in the future, it will be widely used as an assistive technology to help professionals to perform their work more accurately and efficiently. There will be an increasing need for the organizations to develop processes for change management and to collaboratively innovate intelligent business processes for the AI capability to be adopted successfully. As richer and more diverse data floods into the healthcare systems, there will be an increasing expectation for AI to turn it into usable insights. There is a hope for AI being able to support more accurate research and development in healthcare, leading to better outcomes, lower costs, and greater efficiency. (Lovell, 2022.)

Artificial intelligence is basically a set of complex algorithms that can analyze data and be used as a tool to take full advantage of the digital patient information systems and provide relevant high quality clinical data in real time. There are systems being developed that utilize deep learning that can reveal subtle models from medical images, laboratory tests and patient data history.

These models can be used to diagnose diseases. Big Data is exploited to develop clinical decision support (CDS) systems that are making personalized medical treatment recommendations for the use of physicians. (Neittaanmäki & Vähäkainu, 2018.)

Covid-19 brought the need to develop the telehealth further and faster and extended the need to come up with technologies to help the healthcare staff with their workload. In this case AI came to help. For example, researchers have been able to predict Covid-19 symptoms three days ahead with the help of AI analyzing data from Oura rings. It seems that AI and wearables are providing hope of earlier diagnosed cases, limiting reinfection, and helping people in returning to a somewhat normal life. (Poongodi et al., 2022.)

According to Klumpp et al. (2021) in the future it will be essential to develop applied AI-solutions to relieve the burden of increased workload as well as being necessary to deliver efficient, effective, and quality healthcare. As Figure 5 shows, the main fields of AI applications for hospitals are care, diagnosis, and logistics, which were seen as having the greatest potential in medical and economical areas through the use of AI. These areas can contribute to agility and efficiency in hospitals by improving healthcare through resource efficiency and service quality, hospital workflow, and value adding processes with the help of AI.

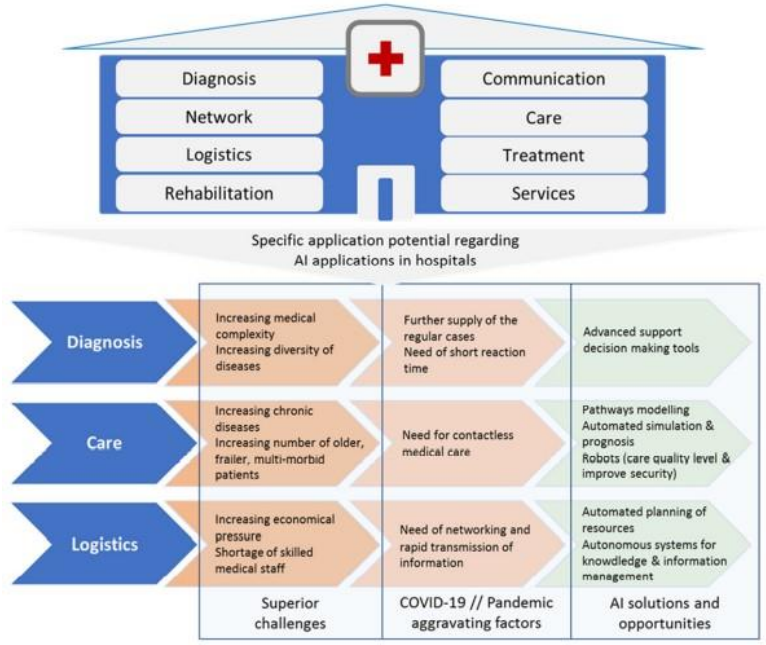


Figure 5. Structure of interrelation of AI application areas for AI in hospitals. (Klumpp et al., 2021.)

There are three areas that Figure 5 suggests for the future development of AI applications to resolve diverse problems that healthcare faces over the world. In diagnostics; advanced support decision making tools. In care; pathways modelling, Automated simulation & prognosis, Robots (care quality level and improve security). In logistics; Automated planning of resources, Autonomous systems for knowledge and information management.

2.2.1 The division of work between human and AI

Studies have shown that when working together, a doctor and artificial intelligence produce better results than either alone. (He et al., 2019.) Artificial intelligence will not replace people, but it gives people a possibility to do more effective work. Taking the most use of exploiting AI does not mean relocating human tasks to a machine, it means enabling co-operation between human and AI to deliver new value and effectiveness. To get the most out of the co-operation, there is a need to re-invent the work processes. This will offer a

huge number of opportunities. The strength of humans includes brainstorming, creative problem solving, and making decisions when intuition and experience is needed. Artificial intelligence has the advantage in information retrieval, routine and repetitive work, and real time processing of large amounts of data without the need for breaks or rest. (Accenture, 2020.)

There is a prevailing fear and mistrust regarding the upcoming increase in the use of technology and artificial intelligence applications. The fear of the unknown raises doubts as to whether AI will replace professionals and eliminate the need for human labor in healthcare. It is estimated that using AI in healthcare will be routine work in ten years in some places. AI will change the tasks and the ways of working for a doctor, some of the tasks will disappear and some tasks will be added to the work routine. The tasks that will be changing or disappearing are related to administration, charting, cleaning as well as diagnostics, image analytics and decision support, hospital resource or clinical workflow optimization, forecasting and drug discovery. But there is not going to be such an embodiment of automation, robot or an algorithm that could replace a professional in the healthcare field. (The Medical Futurist, 2021.)

2.2.2 The benefits of using AI in healthcare

Digitalization and technology are making a huge transformation in society as well as in healthcare. Artificial intelligence is seen as having enormous potential to reduce costs and improve healthcare services and patient care. AI can benefit medicine in finding the relevant information from large data masses and support clinical decision making. AI can help with diagnostics, predicting risks, choosing the right treatments and to improve productivity. (He et al., 2019.)

In the future AI technologies will aid in disease detection and diagnosis, improving outcomes and operational efficiencies. The AI models will improve healthcare's productivity and the experience of satisfaction for both the professional and the patient. (LaRocco, 2022.) AI will help automating the processes, eliminating steps that can drive to human error or error in detection through manual interventions, and it can start eliminating inefficiencies. In the future AI will drive more efficient automation which will reduce human error and start streamlining the overall experience and outcomes that the patients are experiencing. (LaRocco, 2022.)

The conversational artificial intelligence solutions can reduce the workload of professionals, work alongside them to promote customer and patient well-being, and help professionals find the right information or consult on issues related to another service area or specialty. One of the most significant benefits of conversational AI is that it generates data based on the usage information and the AI can be taught to better meet the real needs of its users. The usage data can also be used for wider operational development, to analyze real-time needs for resources as well as to develop other AI solutions. (Accenture, 2020.)

Artificial intelligence can utilize and produce information at all stages, this means that it is both self-learning and self-teaching. The information that is generated from the use of AI can be used to develop artificial intelligence and other services that are based on the needs of the users. (Accenture, 2020.) "Unlike humans, machines with artificial intelligence do not need any sleep, thus overcoming the inherent disadvantage of tiredness in humans." (Borana, 2016.)

2.2.3 The challenges of using AI in healthcare

According to He et al. (2019), the issues related to the sharing of data and privacy, transparency of algorithms, standardization of data between different platforms, and concerns about patient safety have been identified as key challenges related to the introduction of artificial intelligence in healthcare. The challenge is also how to implement an artificial intelligence project in a clinical setting and how to facilitate early acceptance and consider the users. He et al. (2019) explains that the development of artificial intelligence algorithms and their commercialization for clinical use is a very complex process that requires access to huge amounts of data, integration into complex workflows, and regulatory compliance.

Before an artificial intelligence application can be put to the market and taken into use, it must comply with the relevant regulations of a medical device. The manufacturer needs to demonstrate that the device meets the general safety and performance requirements, provide a declaration of conformity, and attach the CE mark to the device. It needs to be demonstrated that the intended use of the device is in harmony with the definitions given in the regulations. A medical device can mean any equipment, instrument, piece of hardware, software, or other item intended to be used with humans for medical purposes, such as diagnosing, monitoring, or treating. (Fimea, 2022.) Getting an application validated and CE-marked for a medical device is a long and demanding process, which is often slowing the implementation of the applications. The complicated processes and the absence of uniform practices is the reason for the prolonged implementation into clinical use. (Pennanen, 2022.)

One of the most significant issues relating to healthcare is data protection, when the data used in the services relates to the most sensitive areas of privacy protection. The issues related to data protection and cyber security needs to be taken care of with special precision. It is also important to openly

and transparently bring to the attention of the user the facts related to the utilization, storage, and disposal of the data, so that the users can decide whether they want to use the service or not. There is also the question of the ownership of the data that accumulates when using the AI applications. (Accenture, 2020.)

When developing AI solutions for the use of healthcare, there comes challenges in the real world. The ambiguity of clinical situations and diagnoses significantly limits the ability to build an accurate artificial intelligence solution. For example, it is not possible to train and validate a classifier for countless medical diagnoses that do not have clear boundaries. There is a need for the medical community to define and recognize a sensible focus for the use of AI. (Lovell, 2022.)

The technology companies' biggest problem has been the healthcare data itself. The companies continually underestimate the problem of "dirty data" in healthcare. The data is full of industry-specific terminologies and formats like ICD-11, RxNorm or MeDRA that are hard to cleanly integrate or align with others. The patient data is contained in many different sources, like lab systems, electronic health records and imaging systems. And making it hard for the machine learning algorithms to interpret the data, up to 80% of it is in unstructured form. (Siwicki, 2022b.)

There can be many kinds of difficulties, including legal liabilities, even if indirect. A good example is if we compare the training of clinical decision support systems (CDSS) to training of clinical decision systems, the first one is much more useful. Not many companies would dare to commercialize solutions with possible problems as mentioned before, even if the AI product itself would be good. There is the question of who is responsible if the clinical AI decision system makes a mistake. (Lovell, 2022.)

One big challenge with taking full advantage of artificial intelligence in healthcare is the financing of the technologies. Municipalities have widespread financial challenges, especially in the healthcare field. There is a need to be

able to clearly demonstrate the cost effectiveness of the technology before committing to ordering it. There is also the challenge of the lack of talent, data and programming skills that are needed in Finland as the demand for these competencies is much higher than what is currently available. (Accenture, 2020.)

3 THE AIM AND PURPOSE OF THE RESEARCH

The purpose of this study was to map out the different artificial intelligence applications and systems used in healthcare in Finland at the moment. More specifically to find out the types and amount of AI applications and their purpose of use. The aim of this study was to create an overall picture of the situation at the moment, in order to increase understanding and knowledge of how AI is used in healthcare and how it can benefit from the use of AI.

The benefits of mapping and gathering the AI applications to one place are increasing the understanding and discovering the use, and the possibilities of AI in the healthcare sector. Understanding how and where AI is and can be used will drive the growth of wider usage and support the implementation of these technologies. Increasing knowledge about the benefits of artificial intelligence adds value to research results. The study also reveals where the information about the applications can be found.

In this study, ‘to map’ is referring to exploring, scoping, scanning, charting and eventually making charts and diagrams of the applications found to analyze and categorize them. In this research, the word application is used as an upper term for all different technologies that use artificial intelligence. The following presents the research questions.

Research questions

1. What kind and in what quantities of artificial intelligence applications are there currently in the use Finnish healthcare?
2. What for and by whom are the AI applications used in the Finnish healthcare sector?
3. Where can the information about the AI applications be found?

4 RESEARCH METHODS

Considering the nature of the topic, the most appropriate research design is a mixed method design, which uses both qualitative and quantitative data, and qualitative and quantitative collection and analysis techniques. As an approach, mixed methods research has a lot to offer especially to health and social science research. The approach offers a dynamic way to address complex and multi-faced research problems, that often cannot be handled by a singular method. (Brandy et al., 2009.) Using mixed methods in a rigorous way, the research in the comprehensive area of AI is more likely to produce useful findings. The main method used is an integrative review.

The integrative review method enables inclusion of versatile methodologies, and it combines and summarizes existing empirical and theoretical literature to comprehensively explain a specific phenomenon or a problem. This method is suitable for complex concepts, theories, and problems in the healthcare sector. Integrative review can be used to develop nursing science and have a major role in evidence-based nursing practice and science. The method is the broadest type of research review methods, and it helps to present different perspectives concerned with including simultaneously results from

experimental and non-experimental research. It can combine quantitative and qualitative methodologies. Integrative reviews contain many kinds of purposes, like defining concepts, reviewing theories, reviewing evidence, and analyzing methodological issues of certain topics. The comprehensive portrayal of complex theories, concepts, or problems is the potential result of an integrative review with the varied sampling frame combined to the diversity of the purposes. (Knafl & Whittemore, 2005.)

Like in every method, there are possible problems in the integrative review method that need to be considered. The complexity that is involved in combining different methods can lead to imprecision, a lack of rigor, and bias. There is a need for explicit and systematic methods for data analysis to protect against bias and to improve the conclusions accuracy. There is a possibility of incorrectly extracted and interpreted data from primary sources and the data analysis may be incomplete or there may not be an accurate synthesis of all information from primary sources. (Knafl & Whittemore, 2005.)

The cross-sectional study method is used in this study. The method can be used flexibly with different research point of views. The main focus of it is that the research concentrates on a certain point of time. It can be used to explore the qualities, conditions, features, and appearances of a topic. The research can use any suitable method of analysis. (Jyväskylän yliopisto, 2010.)

This research consists of the five stages defined by Knafl and Whittemore: problem identification, literature research, data evaluation, data analysis and presentation. (Knafl & Whittemore, 2005.) Identification of the problem is done in the Introduction section. The literature research, the data collection and data evaluation are presented in section 4.1, and analysis and presentation are found in section 5 under the heading of Research results.

The research process which was done according to the mentioned Knafl and Whittemores' (2004) integrative review process, was started with defining and identifing the problem and the research questions. The problem was that the information about the existance and the usage of artificial intelligence

applications in Finnish healthcare was scattered, isolated and point-like, and had not been studied or collected in one place earlier. The research questions set out to determine what for, by whom and how much are AI applications used in the healthcare sector and also what kinds of artificial intelligence applications are there currently in the use of Finnish healthcare.

4.1 Literature research, data collection and data evaluation

The data collection was done with a snowball sampling method. The snowball sampling refers to the samples gathering on top of each other, like a snowball rolling in the snow, and picking up more and more samples on the way until you have enough data to work with. The snowball is a non-random sampling technique, and it is not as uncontrolled as the name might imply. The creation and the progress of the sample is strongly developed and guided by the researcher who strives to ensure that the reference chain remains within the limitations relevant to the research. (Abubakar et al., 2015)

In this study, the form of sampling is exponential discriminative snowball sampling. This means, that during the sampling the researcher is screening through the potential samples before they are accepted to the population. As a result, only the variables that meet the screening criteria are left to be included into the study population. This will improve the reliability of the research outcomes. The screening criteria is presented in 4.2 excluded technologies. With the snowball technique it is possible to find suitable samples, and the results are highly relevant to the research context. The disadvantages of the exponential discriminative snowball sampling is that it is time-consuming, the representativeness of the sample is not guaranteed, and there is also a risk of sampling bias. (Abubakar et al., 2015; Formplus, 2021.)

The aim of the data collection was to ensure that the sample is comprehensive, despite its discretion. Snowball sampling is suitable in this case because the

information about the AI applications can be found in clusters, and when there is something found that will fit the criteria, it might lead to other similar sources. Therefore, the snowball technique suited the purpose of the study.

Before starting the data collection, the restrictions and wanted features for the study population needed to be defined. The restrictions were that the application needed to be used in relation to healthcare or to health and welfare, either directly connected to medical care, or prevention of health related risks or illnesses. The applications need to be in actual use in the year 2022, with trial runs and prototypes being excluded. The excluded technologies are presented in the chapter 4.4.

The data search began by going through different scientific databases, Samk Finna, Finna, Medic, Pubmed and Cinahl. Restrictions were set to specific years (2018-2022), full text available, and text available online. Mainly articles that were written in Finnish have been applied because the study is done on the applications used only in Finnish healthcare. Articles written in English concerning Finnish healthcare were also included, but often the English written articles were not concerning only the applications used in Finnish healthcare.

The search word combinations were (artificial intelligence OR AI) AND (healthcare) AND (Finland OR Finnish) and the same in Finnish (tekoäly AND terveydenhuolto AND Suomi). This search resulted in finding some information about the use of AI in healthcare, but not many actual applications were found through these searches. A few results remained as a source in the background section of the study. As AI in healthcare is a popular subject in articles and studies, there are not many that present the applications that are in use of Finnish healthcare. Because the data could not be found through scientific databases the search was extended to the internet and most of the data was collected through searches via Google, or going directly to organizations and companies web pages and doing interviews.

As the search was extended to the internet searches, the same words were used in the Google word search as in the scientific database search. The

words were (artificial intelligence) AND (healthcare OR hospital OR doctor OR health) AND (Finland OR Finnish). These words were used in the internet search only in Finnish, because of the problem mentioned before. The results were reviewed systematically and combed through for suitable applications. The search was an iterative process and took quite a lot of time. Every application needed to be found and evaluated individually and carefully. A few searches resulted in multiple findings, such as the web sites of Business Finland and Finnish Istitute for Health and Welfare (THL). There were also found articles or web pages which lead to other sources of applications.

Contrary to the original research plan, the research method required contacting the companies and service providers, because the information about the AI applications was not always accessible on the web pages or the information about the usage of AI was not clear. The response activity from the contacted companies varied a lot and partly remained low. If there was no response to the inquiries, the application was excluded from the research. Some of the information was gathered at the HIMSS 6/2022 expo, where many of the Finnish health and medical technology providers were present. The data collection at the expo was done by contacting and interviewing the company representatives about their product possibly using AI. The data was also collected after the expo by going through the companies internet pages and confirming and expanding the information received during the interviews.

The contacts were made through email after there was not enough data found about the AI application from internet. There were fifteen emails sent and six of them resulted with the application ending up in the results of this study, rest of the contacts were eighter not answered or the application was not using AI. Based on these contacts the excel list was supplemented.

Data was collected during the year 2022, starting at the beginning of the year and the data collection came to an end at the end of October. The innovation and implementation phase of products and applications in the welfare technology industry is so widely accelerating at the moment, that the collection of the possible new applications could continue on as long as there are new

applications to be found and on the other hand the time for this research was limited. However, despite this, the study population is comprehensive.

4.2 Data analysis and presentation

In an integrative review the data from primary sources is ordered, coded, categorized, and summarized for the data analysis. The goal of the data analysis phase is a thorough and unbiased interpretation of primary sources and an innovative synthesis of evidence. The integrative review data analysis method consists of data reduction, data display, data comparison, conclusion drawing and verification. (Knafl & Whittemore, 2004.)

In this study the data analysis has been an iterative process. The data reduction was done during the data collection. Only the applications which meet the screening criteria have been chosen for the study population. There was reduction done also during the analysis of the data because the web pages of two of the applications were closed and after a web search there was no information about these applications found. This shows that there is a lot happening in the industry at the moment, many new companies are born, others are amalgamated, while some do not make it.

First the data was collected to a list, where the application, the information about the applications use, and the reference was recorded. After this the data was coded and organized into an Excel sheet and the categorizing was done with the different attributes that were created during the data collection period. At first there was an attempt to use a deductive method of analysis by finding a ready made categorizing scale from articles and studies. But when the data started to gather, it seemed that the scales that were found, did not quite fit the analysis needs of this study population. That is why the categorizing and analysis attributes and scales were created using an inductive method to

match and analyze this particular study population. The attributes and categories are presented in the result section.

The data is displayed with different charts, diagrams, and tables. The organizing, coding, and categorizing of the data is done with Excel and the charts were created with Excel. The charts presented in Table 1 and 2 were made with PowerPoint with the gathered data from the Excel sheet. PowerPoint was used to create Figures 6 and 11 and Figures 12-14 were created with Discords Midjourney application.

The data was analyzed and compared by examining the data displays and identifying patterns, themes, or relationships. In the quantitative analysis the data is calculated by categories. Conclusion drawing and verification are the final phases of data analysis. In this study the conclusion is drawn in the last chapter of the study, where it is summarized, what is known about the topic and what this paper adds to it. (Knafl & Whittemore, 2005.)

4.3 Reliability and trustworthiness of the research

The research method has been comprehensively presented, the research process has been made transparent and the reasoning has been justified. The screening criteria for the study population was made clear. Transparency of the research was increased by the fact that the applications have been presented in the appendices and they have been clearly analyzed and categorized. Reliability was also increased by making visible the sources and the places where the data was found.

Qualitative content analysis can be used in either an inductive or a deductive way. Deductive research takes a theory as its starting point, which is then empirically tested. Inductive research starts from the material. Deductive research is more clearly connected to quantitative, and inductive to qualitative

research. (Elo et al., 2014.) This research uses both but concentrates more on the inductive research method.

According to Elo et al. (2014) both of these analysis processes involve three main phases; preparation, organization, and reporting the results. In the preparation phase the suitable data is collected for content analysis, making sense of the data, and selecting the way of analysis. The organization phase includes open coding, creating categories, and abstraction. Finally, the reporting phase describes the results by the content of the categories which describe the phenomenon. (Elo et al., 2014.) These phases are followed in this study and the phases were explained thoroughly earlier in this chapter, which increases the trustworthiness and reliability of the research.

Challenges concerning the method relates to the repeatability of the research as Google optimizes search results for the one doing the search. If there would be a study done with the exact same searches, the results could come out different. Same challenges occur with the data collected from the HIMSS22 fair and exhibit and personal contacts.

4.4 Excluded technologies

The data was evaluated during the collection and analysis periods. There was a need for strict boundaries to filter out applications that are not suitable for the study. Evaluation was done according to the predefined criteria. In this research the screening criteria was that only AI applications are used, which are directly relating to clinical healthcare and medical work. As the data collection proceeded, the criteria developed and became more specific. Both preventive and treatment related applications and the systems that are used by the healthcare professionals or the patients were accepted to the study. Only the applications that were in use in Finland in 2022 were taken into account.

In this research the technologies regarding pharmacy and dentistry were excluded from the data, as well as healthcare administration. There were a lot of results found concerning AI used to develop and research medicine and new kinds of bio- and combination medicines. AI is also used for patient flow and resource management, but this research does not include those technologies. (Neittaanmäki & Vähäkainu, 2018.)

There are artificial intelligence applications being developed and tested with university hospitals and big companies, but they are still in testing phase, and some are used in clinical trials, and not in actual clinical patient work. These applications are also excluded from this research.

The usage of artificial intelligence is becoming more common in radiology and surgery, but with this study method there were challenges to find the information needed to map all of these applications being used. There were a few found that are included in the research results, but the results do not cover the extent of the potential prevalence of surgical and radiological applications. Figure 6 shows the screening criteria both the included and excluded technologies.

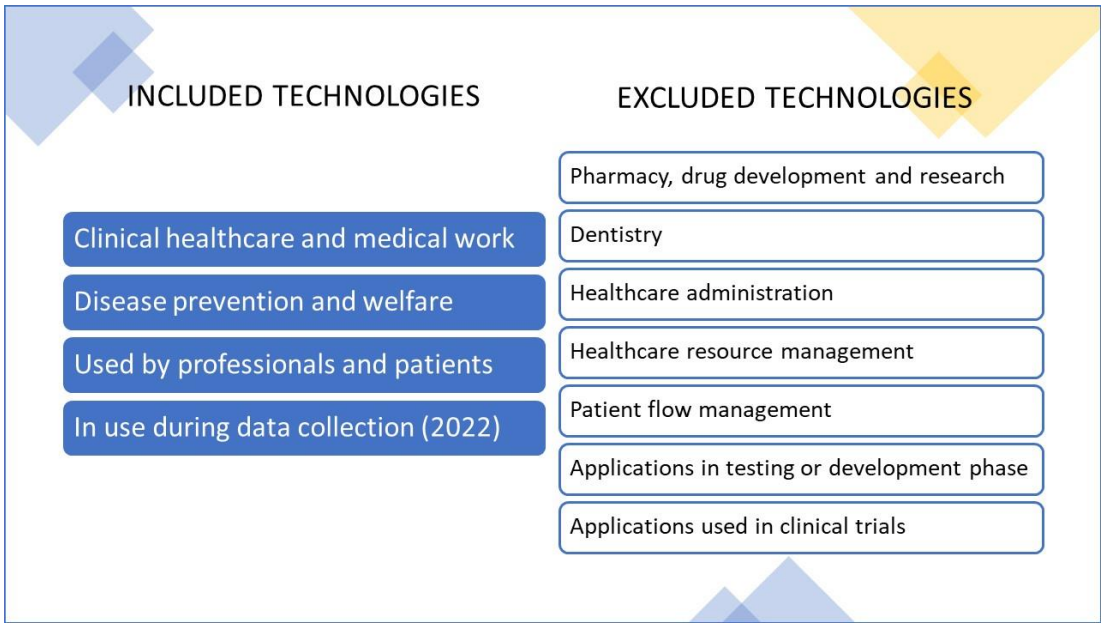


Figure 6. Included and excluded technologies of the research.

5 RESEARCH RESULTS

This study was conducted by researching the use of artificial intelligence in Finnish healthcare. There were more applications found in different parts and sectors of healthcare when compared to prior expectations. Also, many studies and articles were found concerning how AI can or could be used in the future. Based on the research results, AI is already taking its place in Finnish healthcare, but the larger conquest of the field is still in its early stages and under development. Laws and regulations are one of the reasons slowing the implementation process of AI innovations. There is a lot of information about using AI in healthcare around the world.

As was explained before, this research consists of the five stages defined by Knafl and Whittemore (2005): problem identification, literature research, data evaluation, data analysis and presentation. The last three stages are presented in this result section. The research results are included as a chart in APPENDIX 1. All together there were 84 applications found through this research. In this result section the data is categorized, charts are used to categorize and analyze the results and they work as a supplement to the data presentation. The categorizing method is used which was created for the results of this study. This chapter answers the research questions presented in section 3. Aim and purpose of the research. The applications are analyzed by defining what kind of applications were found, what for, and by whom the applications are used and how many are there.

5.1 The AI applications used in Finnish healthcare

This chapter presents the results for the first research question, what kind of, and in what quantities artificial intelligence applications are there currently

used in Finnish healthcare? All of the categorized results can be seen in Figure 8. The first categorized groups (in the horizontal column of the charts) define what the applications are and what are they used for; the first group is for chatbots and virtual assistants' (21). There are multiple chatbots that assist customers in directing their contacts in the right places and guide them with their symptoms and questions. A few examples of these are Omaolo, TerveysHelppi, and Milli- virtual assistant. Quite many of them were built for Covid-19 related contacts, like FrontAI koronabotti and Åbot. They are built to preform symptom checks, make corona test referrals, test appointment bookings, and result handling.

The second section is for the applications that are designed for the assistance and the use of the healthcare professionals (24), like decision support systems and parts of patient health record systems. In this group the applications have a wider range of functions. There are applications that gather data and analyze it to help with the professional's decision making, like EBMEDS clinical decision support system and Comprehensive Medication Review. There are applications that help with diagnosing, analyzing different tissue or imaging samples, making analyses and classifications of the results, such as Aiforia and MVision. There are few dictation apps, that make the documentation phase more fluent and time effective, like Inscripta Medical. Some of them analyze and predict a person's health risks or the status of a long term illness, gather data and then give alerts about the situations that need attention, for example Forsante, Rehabscreen and ProWellness. All of these applications make the professionals work more efficient, cost and time effective.

The third section is about the applications that are made for monitoring and surveilling (20) patients, their symptoms, and vital functions. Applications like Gillie.AI, Awario, Vesratio and Cerenion C-Trend are good examples of this group. Most of these applications are used for remote monitoring, often for the benefit of homecare services. There is some kind of device or hardware used to gather the data in most of these monitoring applications. The fourth section is mostly in the radiology and pathology area, where applications are used for screening (14), like Varian medical system, End-Aid and QuPath. These

applications are used in radiology and pathology, for example with RTG, CT, mammography, magnetic resonance imaging, largely for cancer detection and treatment. The fifth group consist of robotics (3), of which one is a surgical robot Da Vinci, and the two others known as Smila and Eve-medication robots are used as an aid to medical treatment. Figure 7 shows the kinds of AI applications found by this research.

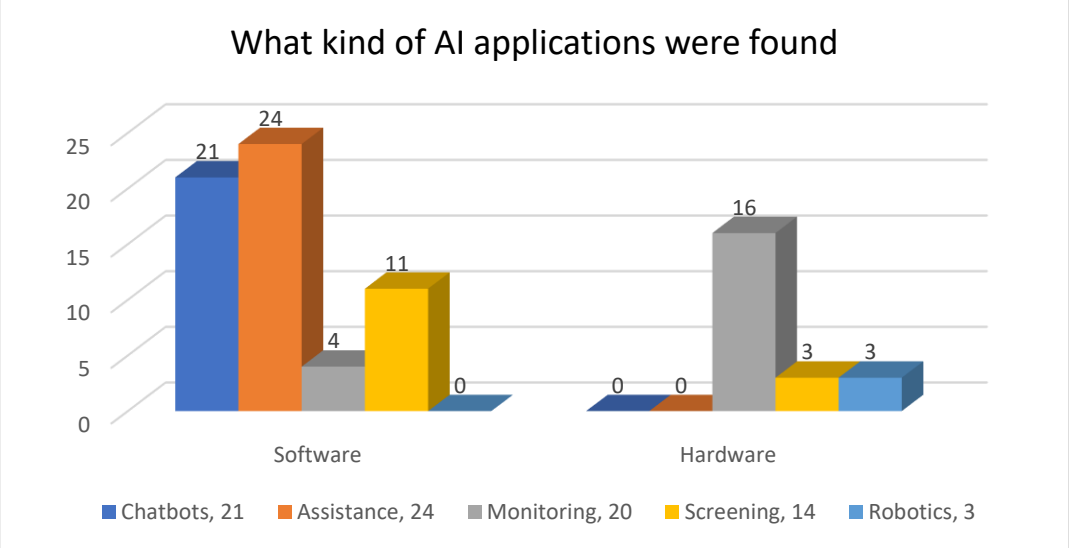


Figure 7. The division of the applications to software and hardware.

The groups in the vertical column analyze the applications usage. All of the applications are based on software, and the hardware category is for the applications that use a device or hardware to monitor, screen or gather data. If the application is using hardware, it has been only added to the hardware group, even if all of them are using software. If there is no hardware in use, the application belongs to the software group.

Most of the applications are based only on software (60) and a hardware/device is used by 22 of them. The hardware/device is in use mostly in monitoring and surveillance applications (16), and all of the robotics are hardware. In three of the screening applications there is a hardware/device attached. Mainly the hardware/devices are used by professionals for preventive care and diagnostics. The applications that are only using software are mainly for assistance to professionals and chatbots/virtual assistants.

5.1.1 Quantity of the AI applications in Finnish healthcare

In this study, Excel is used for quantitative analysis of the results. The excel sheet can be seen in APPENDIX 1, where all the applications are listed and categorized as explained earlier. In this research, there were 84 applications found that are using artificial intelligence in the healthcare sector in Finland: 21 of them are chatbots and virtual assistants, 24 belong to the category of applications that assist the work of professionals, like decision support systems and patient health records, monitoring and surveilling applications are 20 of them and for screening are used 14 of the applications. A device or hardware is used in 26 of the applications, including the three robotics solutions. Figure 8 shows all of the applications and all of the categories in the same chart, from where they have been analyzed and compared to each other.

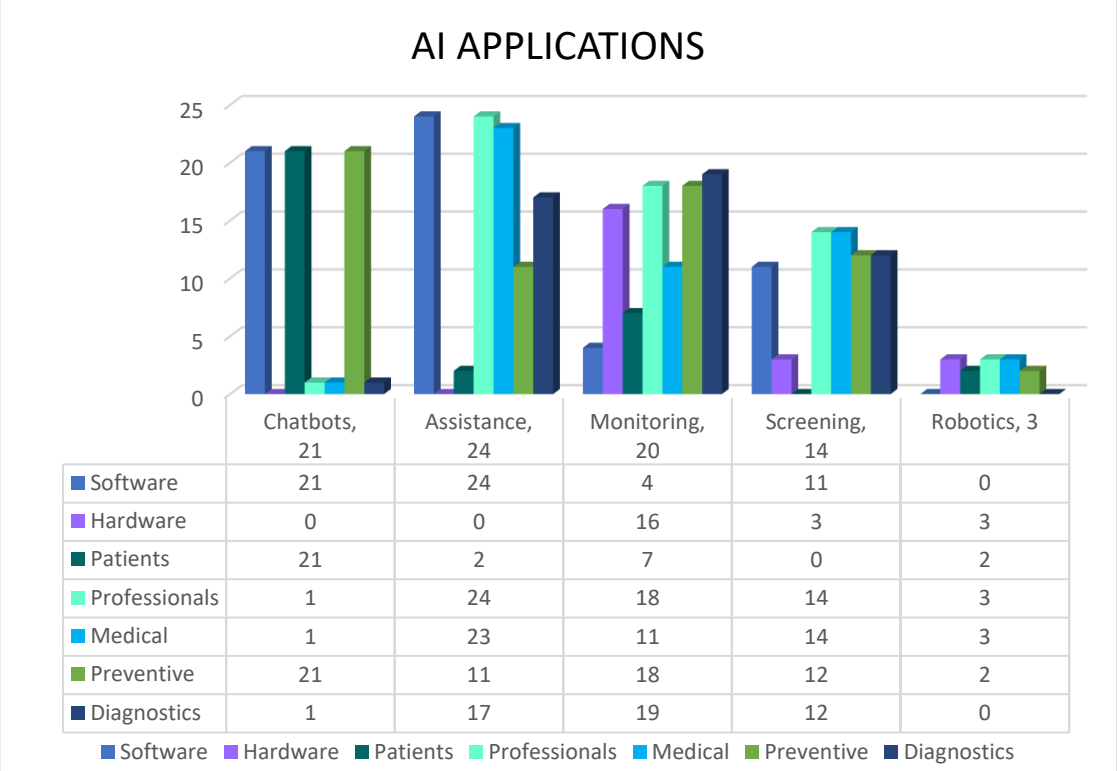


Figure 8. A chart of the application categories and purpose of use.

Thirty-two of the applications are utilized by patients, whereas in professional use are 62 of them. Ten of the application are designed to be utilized by both patients and professionals. Fifty-two applications are used for medical care and designed for preventive care there are 64, 32 are used for both of them. For diagnostics are used 49 of the total amount, one from the chatbot/virtual assistant group, 16 from the assistance of the professionals' group, 19 of the monitoring applications, 12 of the screening applications and 20 of the hardware/devises are used for diagnostics.

As we can see from the Figure 8, the applications for professional assistance is the biggest group with 24 applications, followed by 21 chatbots/virtual assistants and 20 monitoring applications. So based on this we could say that at the moment, artificial intelligence in healthcare is used for assisting professionals in their work, helping patients get answers to their health problems, guiding them forward and to facilitate contact in health matters and it is used for monitoring and surveillance, often with the help of a device (20).

If the chatbot/virtual assistant group wasn't in the count, the charts would look quite different. There would only be a few applications in the use of the patients, mostly in the area of monitoring and surveilling. Also, the emphasis on the medical care would be larger.

5.2 Users of the AI applications in Finnish healthcare

In the analysis, patients and professionals' groups are divided by the utilization aspect of the application: for whom, and for what benefit. In many cases the applications can be utilized by both professionals and patients. Figure 9 shows the patient-professional group categorization of the AI applications, that were found by this research. As can be seen from the chart, there are more applications utilized by the professionals 60, that the patients 32.

Patients mostly use chatbots and virtual assistant applications (21), some of the monitoring applications (7) and two from the assistance (2) and robotics groups (2). The chatbots and virtual assistants are mostly utilized by patients and are usually used for preventive care. Whereas professionals utilize the assistance applications (24), monitoring (18) and screening (14) applications and all three of the robotics solutions (3). The applications for professionals' aid, like decision support systems and patient health records are utilized mostly by professionals and often used for medical care and diagnostics, and 10 of them are in preventive care use. Monitoring systems are utilized more often by professionals for preventive care and diagnostics.

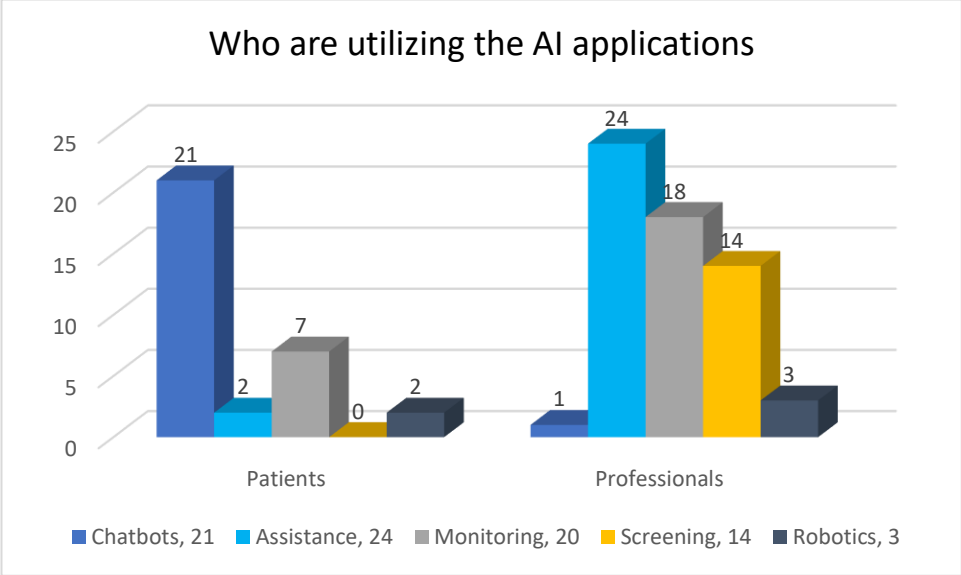


Figure 9. Who are utilizing the AI applications.

There is a clear distinction between the users of certain applications. The technologies designed for patients are chatbots and virtual assistants, which are not used by the professionals, but they also aid the professionals' work. Some of the monitoring and surveillance applications are used by both, but they are not yet made to be used by the patient without the control of a professional.

5.3 Purpose of use of the AI applications in Finnish healthcare

The Figure 10 shows the results for what are the AI applications used for. The categories of the usage are medical care, preventive care, and diagnostics. The medical care group relates to any medical care and treatment process of a disease or illness, the applications are planned for medical usage, while the preventive applications are used in prevention of illnesses or health related problems or welfare. The diagnostics category defines the applications that are made to assist in some part of the diagnosing process. These groups can be seen in the Figure 10.

The definitions about the usage of medical care and preventive care can be difficult to determine from each other, they also often overlap and intersect. The separation between groups, can be difficult to define, because most medical treatments can include prevention and preventive care and can often be also considered as treatment. For example, medication can be viewed as both treatment and prevention. The analysis is done by dividing the applications by the first target or aim that the application is designed for, but of course some of them do both.

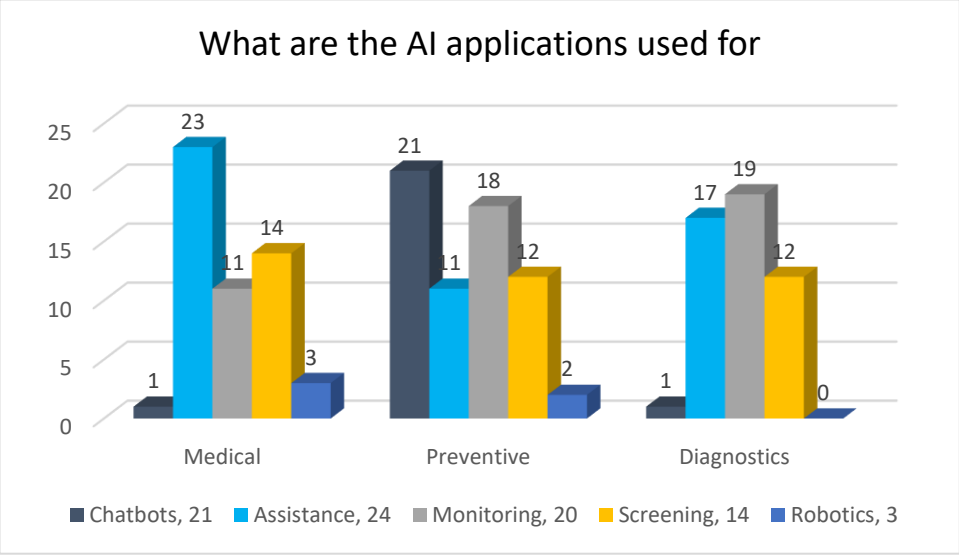


Figure 10. What are the AI applications used for.

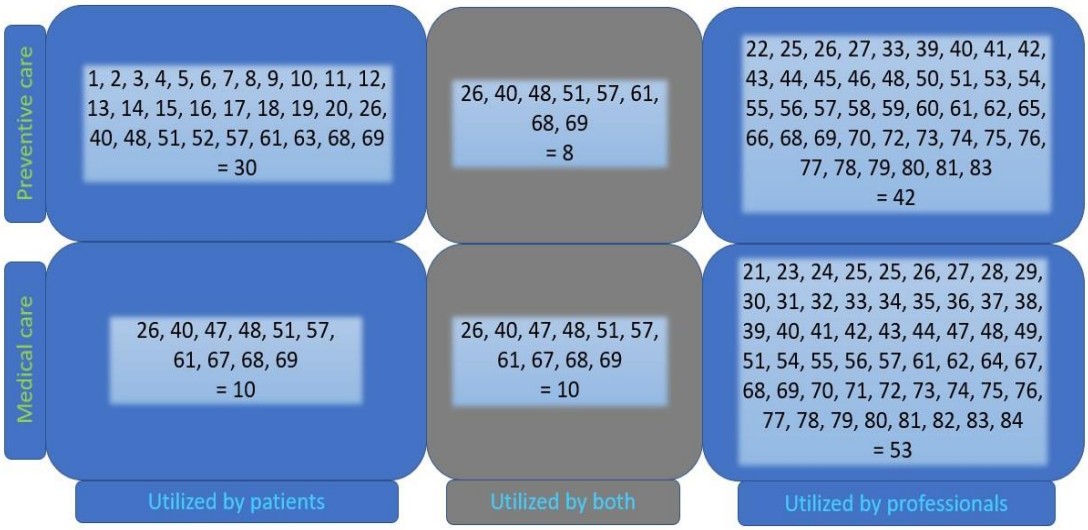
All of the chatbots and virtual assistants are used for preventive care (21) and only one of them is also used for medical care (1) and diagnostics (1). The applications for the assistance of the professionals are mostly for medical use (23) and often they assist in diagnostics (17), while less than half of them are used also for preventive care (11). The monitoring and surveilling applications are used in all of these groups, and almost all of them assist in diagnostics (19) and in preventive care (18), while over half of them are used in medical care. The screening applications divide quite equally to all of the three groups medical care (14), preventive care (12) and diagnostics (12). The robotics are all connected to medical care and two of them apply also to preventive care (2), but they are not included in diagnostics. Diagnostics is concentrated on monitoring, assisting, and screening.

AI applications are used firstly for the assistance of medical professionals in medical/ treatment related care, secondly AI is used for the help of patients through chatbots and virtual assistants, thirdly it is used for monitoring in preventive care and diagnostics. If total amounts are summed up, most of the applications are used for preventive care 64, second is medical care 52 and diagnostic applications are 49.

5.3.1 Usage and users of the AI applications

In this chapter are two tables that are used to present and categorize the AI applications. In Table 1 can be seen the applications by usage and users. The numbers in each field refer to the listed applications that were found by this research and like mentioned before, the list can be found from the APPENDIX 1.

Table 1. AI applications categorized by their usage and users.



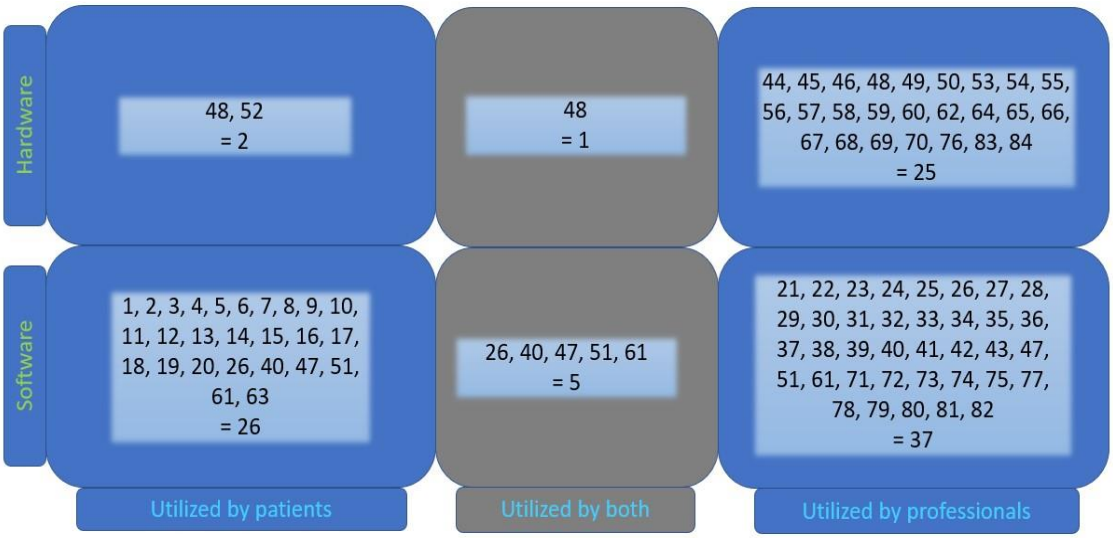
In the Table 1 the AI applications are distributed by four main attributes; software, hardware, utilized by professionals, and utilized by patients. To the grey box in the middle, is added the applications numbers and amounts which are utilized by both. By software is meant any application which is only used as a software, such as decision support system or medical patient record. In the hardware section there is some sort of a device, or hardware connected to the AI application (software). By professionals it is meant the registered healthcare professionals working in the field, such as doctors and nurses, are included in the “Professionals” category. Patients are defined as the people who are using the services of the healthcare sector, such as patients, and customers.

Table 1 shows that most of the applications are utilized by the professionals and more often they use the applications for medical care (53). Professionals used 42 of the applications for preventive care and this shows a difference of 11 applications between the preventative-medical category. Patients utilized 10 applications for medical care and 30 applications for preventive care. This chart shows that the applications designed for patients concentrate on preventive care and the applications made for professional usage are mostly built for medical care, but many of them can be used for preventive care too.

Applications for preventive care, eight applications are utilized by both professionals and patients and for medical care ten applications are used by both. A big part of the applications for professionals are used for both medical and preventive care, whereas a larger part of the applications for the use of patients are mainly for preventive care. This means, that for the use of AI in medical care, there still needs to be a healthcare professional involved, AI cannot give full guidance or make complete decisions related to medical care, yet. Whereas preventive care instructions are easier to give on a general level and after this, the responsibility is left to the patient.

In the Table 2 the horizontal attributes patient-professional usage are the same as in Table 1. The grey section between collects the applications which are used by both. The vertical attributes are software and hardware. The explanations of these attributes can be found in the beginning of this chapter. From the four field we can see that again most of the applications are utilized by professionals (62) and most of them are using only software (63). The applications utilized by professionals concentrate on apps that use software (37) and there are 25 that makes use of hardware or a device. There are 26 software applications utilized by patients and only 2 applications that use hardware.

Table 2. AI applications categorized by the way of use and user



From this it can be interpreted that a large part of the applications that make use of a device or hardware is utilized by and designed for professionals. By analyzing the applications using software, most of them are for professionals, and most of the patients' applications are only using software, five of them are utilized by both professionals and patients, and only one hardware application is used by both. Utilizing a device is still more rare, than using AI software and it is uncommon to have an AI application using hardware solely for the use of a patient.

5.4 Information sources of the AI applications

This section answers to the third research question about the sources of the data. As was mentioned earlier, the data about the AI applications used in Finnish healthcare was scattered and at times difficult to find and determine if the technology was using AI or not. At first the data was searched through scientific databases. There were two articles found which listed applications, but they were used all over the world and not in Finland, so they were not accepted to the study. Therefore the search expanded to the internet. Internet searches were done as was described in the data collection section. Most of the internet searches produced findings of individual applications, whereas some of them provided chains of findings, such as Business Finland, Healthtech Finland and THL/Hyteairo sites.

When internet searches came across challenges, the research expanded to interviews and direct contacts with companies and service providers. There were fifteen emails sent and six of them resulted with the application ending up in the results of this study, rest of the contacts were either not answered or the application was not using AI. Based on these contacts the excel sheet was supplemented.

Figure 11 shows the five main sources from which most of the information about the AI applications were found. 23 apps were found via Google, with some sources mentioned in the lighter bubble next to the Google results. The second most information was found on THL & Hyteair's website, where most of the chatbots and virtual assistants were found. Seventeen applications were found in the Business Oulu cathalogue of Health Life Science where health techology companies were listed. This catalogue was found through HIMSS22 Fair & Exhibition, when having a conversation with the representatives of Business Oulu. Eight of the applications were gathered at HIMSS22 fair after interwieving the company representatives. Ten of the applications were found through the webpages, blogs and newsletters of Business Finland. Seven applications were given leads from personal contacts who are working in some relation to the field, e.g. a surgeon.

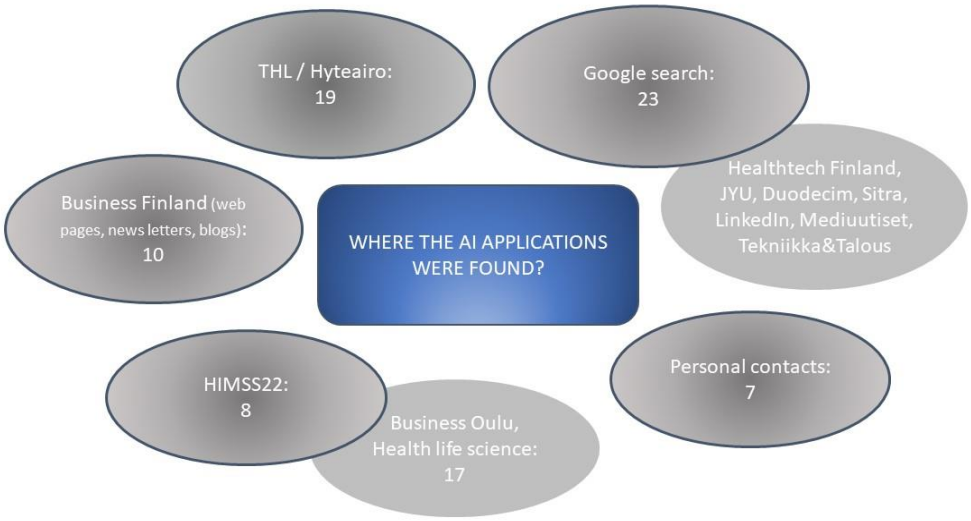


Figure 11. A chart of where the AI applications were found.

6 DISCUSSION

Neittaanmäki & Vähäkainu (2018) stated that, in order to succeed, doctors must change their previous practices and attitudes to cope with the new technologies. Dr. Bertalan Meskó (Medical futurist, 2022) shared a comment that, “AI will not replace medical professionals. However, those medical professionals that use AI will replace those that don’t.” The technological change is here, and it will affect everyone. Artificial intelligence will change the practices and usage of healthcare and medicine, but it will not replace the professionals working in the field. AI has the possibilities to help in making their work more efficient, effective, and safer. It is discussed that AI will become a powerful tool and an assisting coworker for health professionals. The results of this study speak on behalf of this.

For the visualization of the thesis, the results of this study were compressed to a few words and sentences and then an artificial intelligence software Midjourney in Discord was used to create pictures of the results. The words and sentences used were “Artificial intelligence and healthcare” and “Artificial intelligence used in healthcare” and “Artificial intelligence and healthcare professional working together” and “Artificial intelligence assisting in diagnostics” and “Artificial intelligence assisting professionals” and “Artificial intelligence helping patients” and “Artificial intelligence monitoring, and screening patients” and “Artificial intelligence analyzing results” and “Robotics” and “Chatbots for patients”. The Figures 12, 13 and 14 were created by using different combinations of these words and sentences. The study results visualized through the eyes of artificial intelligence are shown in the Figures 12-14. These can be considered as artificial intelligences self-portraits while working in the healthcare sector.

Figure 12. AI self-portrait of working in healthcare. (Jenni Myllylä/Midjourney, 1/23.)

6.1 Utilization of AI in Finnish healthcare

Based on the results, at the moment artificial intelligence in healthcare is used for assisting professionals in their work by gathering data and analyzing it and participating in the diagnosing process. AI is helping patients with facilitating their contacts and getting answers to health problems and guiding them forward. AI is also used for monitoring and surveillance of patients, their symptoms, and vital functions often with the help of a device/hardware. When comparing to the literature review results, this thesis study revealed similar areas where AI is used in healthcare at the moment.

In the background section of this study, the results of the literature review about the usage of AI in healthcare were presented. Neittaanmäki & Vähäkainu (2018) wrote that AI is used for diagnosis, making treatment recommendations, and in surgery. Rodriquez (2016) mentioned AI in healthcare means the utilization of data processing as an intelligent tool to aid professionals in clinical evaluation and decision making. The main areas of AI-based healthcare are clinical decision making, healthcare interventions, automatic care and healthcare process recommendations, patient administration, and patient monitoring. (Väänänen et al., 2020.) The results of this study were similar, as it showed that AI in Finnish healthcare is used mostly for the assistance of the professionals in decision making, diagnostics and healthcare interventions as well as in monitoring and screening. In most of the applications AI is used for collecting and analyzing the gathered data.

The general aim of using AI in medicine is to use the algorithms to reveal useful information from the healthcare data and to assist the professionals in clinical decision making in diagnostics, selecting treatments, and predicting risks. (He et al., 2020.) The results of this study found that most of the AI applications are designed for these purposes and in this way, they can make the professionals work more effective, and efficient. This can become an important tool in the future. A big part of the applications in the study results participate somehow in the diagnosing process, but there were just a few actual clinical decision support applications found. It can be that a large part of these applications are still waiting for the development of the technologies, and for the loosening of regulatory restrictions.

Väänänen et al. (2020) named AI technologies which are used in the healthcare sector, and these were also found by this study: robot-assisted surgery, virtual assistants for nursing and consultation, dosage error reduction, connected machines, preliminary diagnosis, image diagnosis, medication management and health monitoring. There was one technology that was mentioned by Väänänen but was not explored in this research and it was fraud detection. From the areas mentioned in the literature, the excluded areas for

this study were concerning the assistant for administration and workflow, clinical trial participation, cybersecurity, and drug creation, however they were noticed during the data collection. A few of the applications found by this research relate to predicting risks and selecting treatment plans, but based on the findings concerning the future, those are going to be lot bigger areas for AI. Also, clinical decision support is going through major progress when the AI applications and algorithms develop further.

This study revealed that AI applications that were designed for and used by patients were for the most part chatbots and virtual assistants. They are used in helping patients get answers to their health problems, guiding them forward and facilitating contact in health matters. AI applications will have an effect on patients receiving better and faster access to care. Even though professionals are not using them, these applications will also save a lot of professionals' time in the future, when AI can take the load from the first contacts, booking appointments and simple guiding tasks. The applications that were designed for the use of the patients, are used for preventive care. The applications that give advice with the help of AI on a general level, are much easier and lighter to build, than it would be to design a patient operated AI application which guides and makes decisions on medical treatment for example the provision of medication instructions. There are still too many legal, regulatory, and ethical problems concerning the liability questions. This might also be the reason why there were not many AI applications using hardware or a device designed solely for patient use. There still needs to be the supervisory and monitoring responsibility of a healthcare professional related to the use of these applications. They will surely become more common for patients' home usage in the future when AI technologies are developed further, and the responsibility issues are solved.

Chatbots and virtual assistants use Natural language processing (NLP), and its subfields Natural language understanding (NLU) and Natural language generation (NLG). NLP can plow big masses of information and it allows automated processing and analysis of free unstructured text. NLP can process both text and speech. (Allot et al., 2021; Ponraj, 2020.) NLU focuses on

interpreting the correct meaning and purpose from the data. NLG is used for generating the response text. One sub-concept of chatbots is a conversational artificial intelligence, which is used between a human and a machine by using a text or speech interaction interface. Artificial intelligence has been taught to understand the human language. (Accenture, 2020.) Some of the chatbots were even taught different dialects, and ways of spoken language. The conversational AI chatbots are still in early stages of Finnish social and health care, even though there were many found. The solutions are mainly customer service virtual assistants, which are used for general advice and guidance to customers and patients such as directing customers to other services. Clearly the development of these applications has taken a big leap during the Covid pandemic and many of the chatbots from this research results are related to Covid, symptoms of disease, testing and vaccinations.

When comparing the results of this study to the Figure 4 of He et al. (2019) about the roles of AI-based technologies now and in the future, there were similarities in the diagnostics section, while some of them are still in the development phase i.e., expert-level diagnosis applications. While the results from this study concentrated more on the applications used by professionals, evidence was found showing that there are applications under development for population health management, such as the monitoring devices for the patient usage for early disease detection. The many virtual assistants and chatbots can also be counted in this category for their healthy lifestyle promotion and public education abilities. There are patient-centered information systems under development as well.

In the Figure 4 therapeutics are mentioned, like EHR data and clinical guidelines, where AI is used for treatment of common diseases and Human-AI interactions in robotic surgery which were both found by this study, as well as the data-driven precision medicine to deliver therapies guided by AI. Drug interactions and complications as well as disease monitoring applications were found in the results of this study. Applications of pharmacogenomics for guiding drug therapy were excluded from this study.

Figure 13. AI in healthcare visualized by AI. (Jenni Myllylä/Midjourney, 1/23.)

Figure 5 from Klumpp et al. (2021) described the different needs and results for the use of AI applications in the areas of diagnostics, care, and logistics. The needs to be answered in diagnostics with AI applications were concerning the increasing medical complexity and diversity of diseases, the increasing number of cases needed to be diagnosed and the need for a short reaction time. As was detected by this research, AI has the ability to come to the assistance of the professionals in all of these problems with advanced support of decision making tools. AI is effective with collecting the essential data, analyzing it, and providing it quickly to the situation where it is needed, making the professionals work more effectively and efficiently. This can be related to most of the applications found by this research.

Healthcare sector is having challenges with the increasing numbers of chronic diseases and the aging of the population as well as the increasing need for contactless medical care due to Covid-19. According to Klumpp et al. (2021) AI provides solutions to these problems with modelling pathways, automated simulation, prognosis, and robots. Based on the results of this study, these technologies are still in the development phase and have not yet been implemented into practice. Logistics were ruled out of this study, but it can be mentioned that with the increasing logistic challenges e.g., with the shortage of staff, AI can come to help with autonomous systems and planning of resources.

In this study was found that robotics in healthcare turned out to be mostly automatic, RPA meaning Robotic Process Automation without the use of artificial intelligence. Robotics are in use of healthcare in companion and assistive roles, as a pet that has a calming effect, instructing exercise to elderly people, and also assisting and reminding about medical treatment in homecare and in transfering data from and old electronic patient record (EPR) to a new interface. Covid-19 has also increased the need for robotics and during the pandemic robots have been developed for covid test referrals, result handling, notifications and appointment booking for Covid-vaccinations. These robotics were mostly not using AI.

Robotics using AI were related to logistics in hospitals, tranferring food, medicine and laundry and distributing medication, using autonomous TUG-robots, (Business Finland, 2020.) but these were not related to patient or clinical care, and thus excluded from the study. Three robots were found that use AI, of which one being a surgical robot. Many implications were found for the usage of AI in eye lazer surgery, but the study did not provide enough reliable information about the specific applications in use to include them to the research population.

6.2 Benefits and challenges of using AI

In the future AI technologies can help with disease detection and diagnosis, while improving outcomes and operational efficiencies. The AI models will improve the productivity of healthcare and the experience of satisfaction for both the professional and the patient. AI will help automating the processes, eliminating inefficiencies and steps that can drive to human error. (LaRocco, 2022.) He et al. (2019) talked about how AI benefits medicine in finding the relevant information from a large mass of data and support clinical decision making. AI can help with diagnostics, predicting risks, choosing the right treatments and to improve productivity. These benefits are shown through the results found by this study. Most of the applications were designed to assist and support the professionals in their work by making it more efficient and productive and by aiding in disease detection and diagnosis.

The conversational artificial intelligence solutions can reduce the workload of professionals, work alongside them to promote customer and patient well-being, and help professionals find the right information or consult on issues related to another service area or specialty. (Accenture, 2020.) This benefit best shows in the result of the virtual assistants and chatbots group, as they ease the professional's workload and make the patient contact more effortless with no waiting time, regardless of the time of day. "Unlike humans, machines with artificial intelligence do not need any sleep, thus overcoming the inherent disadvantage of tiredness in humans. "(Borana, 2016.) This benefit also covers many other applications.

The results of this study also support the idea that other studies have shown about the division of work; a healthcare professional and artificial intelligence produce better results together than either alone. (He et al., 2019.) The AI applications will come as a useful tool and a supporting coworker to the professionals in the healthcare sector. They both have their own strengths: the human advantage includes brainstorming, creative problem solving, and

making decisions when intuition and experience is needed. Artificial intelligence has the advantage on information retrieval, routine and repetitive work and real time processing of large amounts of data without the need for rest. (Accenture, 2020.) The applications in the results of this study represent the qualities mentioned here, as they retrieve large amounts of information, process and analyze it and preform different routine and repetitive work. They support the work of the professional and make it easier.

Figure 14. Artificial intelligence created visualization of AI in the use of healthcare. (Image made by Jenni Myllylä, 11/22, using the AI tools in Midjourney.)

There were many challenges also presented in the chapter of Artificial intelligence in healthcare. Pennanen (2022) talked about getting an application validated and CE-marked for a medical device is a long and demanding

process, which is often slowing the implementation of the applications. The complicated processes and the absence of uniform practices is the reason for the prolonged implementation into clinical use. According to He et al. (2019), the issues related to the sharing of data and privacy, transparency of algorithms, standardization of data between different platforms, and concerns about patient safety have been identified as key challenges related to the introduction of artificial intelligence in healthcare. Furthermore, the commercialization of AI applications for clinical use is a very complex process that requires access to huge amounts of data, integration into complex workflows and regulatory compliance.

There are issues relating to healthcare data protection, the utilization, storage, and disposal of the data, when the data used in the services relates to the most sensitive areas of privacy protection. (Accenture, 2020.) One problem is the healthcare data itself. The data is full of industry-specific terminologies and formats, making it hard for the machine learning algorithms to interpret the data, and up to 80% of it is in unstructured form. (Siwicki, 2022b.) In addition there are the liability issues and the question of who is responsible if, for instance, the clinical AI decision system makes a mistake. (Accenture, 2020.)

These challenges were often encountered while doing this research, especially when interviewing company representatives. Several of them talked about these problems, and several mentioned that the company is working on an AI application, but implementation is slowing down because getting the registration and CE marking for the product, is taking a long time. Many companies going through this development process were secretive about their future AI applications, therefore no information was obtained about them for this study.

6.3 Future of AI in healthcare

Artificial intelligence has the possibility to change the field of healthcare in the future and there are multiple ways AI can affect it. AI can be used to make more accurate and faster diagnoses, find new drug combinations, make treatment recommendations, and save on costs. In the future, hospitals will be full of technology and robotics can be used more and more when performing surgeries, dispensing medication, and helping in logistics, such as transporting hospital supplies. In the future, hospital beds can transport patients all the way from the emergency room, through radiology for imaging, and to the operating room. This helps to reduce the need for personnel. Cognitive computing systems such as IBM Watson helps doctors in diagnosing and making evidence-based treatment plans. Artificial intelligence utilizing cloud-based Big Data and a user interface, are expected to be able to compare information about the patient's illness with millions of anonymously similar diagnosed cases and medical studies in the world. Artificial intelligence also has medical application areas other than the categories mentioned above and can be used to identify eye diseases such as cataracts and it can also be used for mental health diagnosing. (Neittaanmäki & Vähäkainu, 2018.)

There is a massive amount of data in healthcare and most appears in unstructured form in the electronic health records. There is a need for the organizations to make use of that data and plow through all of that text. AI technology that comes to help is natural language processing. It can go through the text and turn it into structured text, making it much more usable and accessible for the healthcare professionals and leaders as well as patients. NLP is already in this use, but when we learn how to take full advantage of the processed data, we can improve health outcomes, identify risks, prevent diseases, and identify patients at-risk. (Siwicki, 2022a.)

In the future artificial intelligence can increasingly be used for the automation of routine tasks and other functions, such as: the already mentioned diagnostic

assistance. With advance treatment planning: certain situations that require the development of treatment plans can benefit from AI tools in this planning stage. Utilizing artificial intelligence applications that automatically create treatment plans based on certain relevant patient situations can bring considerable added value to doctors and patients themselves. Alarms and reminders: in the most common forms of artificial intelligence integration, the computer examines the patient's laboratory results, and drug prescriptions and keeps the patient informed with appropriate reminders. In addition to reminders, more advanced artificial intelligence software can also be used which can identify changes in patients' health. In image recognition, multiple medical images can be recognized simultaneously, from X-rays to complex CT and MRI images. Applications that know how to recognize and interpret the images in question have already been adopted for clinical use. (Jaiprakash et al., 2016)

Watson Health Cloud is utilized for searching for information: search agents using suitable artificial intelligence algorithms can be developed to help complex medical applications which enhance the search for information to a new level compared to the performance of previous Web-based search agents. Patient classification according to urgency, i.e., triage, can be implemented with the help of artificial intelligence and the necessary hardware and systems, and more and more decisions will be made with the help of smart devices. In the future the patient's medical information will be read directly from the chip installed under the skin or from mobile devices, for example a mobile phone or a wearable device, which act as an intermediate step before the chips and implants are installed in the body. In the future, it will no longer be necessary to wait for patient information from electronic systems or to try to find information when the patient is, for example, unconscious or otherwise in a serious condition. (Jaiprakash et al., 2016)

There is a need for continuous research to develop AI algorithms for new medical applications and for improving the existing ones. It is crucial to develop interdisciplinary collaboration between the healthcare professionals and data and computer scientists and engineers, which will ensure that the future

applications provide quality services for both healthcare providers and patients. (He et al., 2019.)

Remote healthcare will become more common and easier to reach for everyone with the help of AI. There are already so many solutions that aim to make the healthcare services more accessible for everyone. One example is YourMD, which is an AI physician in your phone. It is a diagnosis tool for a patient, and it uses AI and machine learning along with trustworthy data. It answers the need of lowering the threshold and making the healthcare services more acceptable. It is much safer than patients using Google to self-diagnose. (YourMD, 2022.)

Oncology is an area in which AI could be able to revolutionize care. Machine learning can benefit physicians by assisting in complex treatment decisions. There is a way of AI solutions to identify and map nearby organs susceptible to cancer risk. Precision in oncology demands the analysis of large volumes of data in an unprecedented way and there is hope that AI will provide patient benefit over the long term. (Lovell, 2022.) If using machine learning and artificial intelligence based on image analytics, it is possible to identify malignant changes earlier in the future as doctors may also be able to better identify the precursors of cancer. Then there can be more effective prevention on their development into actual cancerous tumors. Cancer treatment can also become more individualized compared to the present, providing the opportunity to tailor the best treatment possible with the help of huge amounts of data. (Kallunki, 2018.)

It has been predicted that in the coming decades, the development of artificial intelligence will help defeat cancer with the use of gene manipulation, nanorobots, and artificial intelligence itself. All vital organs can be monitored 24 hours a day, seven days a week with nanorobots swimming inside the veins. Gene therapy will also radically reduce the harms and number of diseases, if not completely eliminating them. Research using artificial intelligence will likely provide effective treatments for almost all types of cancer, and possibly cure some of them. The number of people who die from

cancer will probably continue to decrease with new technologies. (Neittaanmäki & Vähäkainu, 2018.)

There are multiple different ways AI is designed to harness the benefits for society and one of these is the national AuroraAI Programme which is coordinated by the Ministry of Finance of Finland. The aim of the program is to implement an operating model to help people and companies more easily utilize AI-based services easier. It is a public sector artificial intelligence project where the goal is to create an intelligent service network guiding individual services. Its mission is to create technical conditions for the mutual exchange of information and interoperability between different services and platforms. AuroraAI is a good example of cross sector teamwork. (Valtiovarainministeriö, n.d.)

6.4 Reliability, trustworthiness and validity of the research and results

In this chapter the reliability and trustworthiness of the research and the validity of the results have been considered. Transparency of the research was increased by the fact that the applications have been presented in the appendices and they have been clearly analyzed and categorized. The research method has been comprehensively presented and the research process has been made transparent, as was explained in the previous paragraph. Reliability was also increased by making visible the sources and the places where the data was found.

The results of this study are valid and versatile. All the material in this study is collected from diverse sources, which can be seen in the Figure 11. Sources were found from the literature and the articles of the topic, and searching through the internet, from the companies in the field and also via interviews of people working in the field of healthcare technologies (in HIMSS- conference). The material is also collected through contacting the companies in the field

and interviewing the representatives. Reliability and trustworthiness are promoted by the fact that the different sources are displayd and the screening criteria for the study population was made clear.

Validity is related to the research data and reflects how well the data analysis method corresponds to the research data. Reliability reflects how well the method works in the analysis of the material. (Hiltunen, 2009.) In this research the data analysis method is chosen precisely for the research results and the analysis criteria is built for the results of this study. Assessment of content validity relates to how the research process must be assessable, and the reader must be able to follow the researcher's reasoning. The results must not be based solely to the researcher's personal intuition. The material and the interpretations must be described as clearly as possible. (Hiltunen, 2009.) It is important to report how the results were created when assessing the validity perspective. It should be possible to clearly follow the analysis and resulting conclusions. (Elo et al., 2014.) In this study the research process has been made visible, and the reasoning has been justified. The result material can be seen in this report and the interpretations and the report from the results are described clearly.

The research plan was feasible, but the challenges with finding the sources meant that it required work and effort to find all the possible applications and systems that could be found. The information was not easily accessable and it was scattered around the internet and other possible sources, like the developers or the users own web sites. This is also the reason why this study could not be done as a systematic literature review, because there is not enough scientific research done on the subject in Finland. This is why the integrative literature review was chosen, which made it possible to obtain information from other than scientific databases. The research method required contacting the companies and service providers, because all of the information about AI applications was not freely available, the information about using AI was unclear or many of them were not yet reported on the web pages of their users.

The research method suited for the process of the research as it allowed the usage of various scientific and non-scientific sources of data and ways of collecting and analyzing the data. Challenges related to the method were found in difficulties with finding the right data, the uncertainties with contacting the companies and getting answers to the questions. Challenges with the repeatability of the study, as mentioned before, relates to the fact that Google optimizes search results for the one doing the search. If there would be a study done with the exact same searches, the results could come out different. Same challenge relates to gathering the data at the HIMSS22 Fair & Excibition and from personal contacts, these results could not be repeatable.

Like Eva Randén (2017) writes in her blog, that today the term artificial intelligence is used quite loosely and depending on the context, it can mean any advanced application of analytics, such as data analytics, predictive analytics, text analytics or visual analytics. This was noticed when doing this research, there are no strict boundaries for what is meant with artificial intelligence and in which context it can be used. Conversely, even if the description of the technology sounds like artificial intelligence, AI might not be used in the description. This has made the data collection for this study more challenging. Some of the applications, which are mentioned using “intelligent analytics or analyzing algorithms” are also accepted for the results.

The terms analytics and artificial intelligence are often overlapping. Not all analytics meet the definition of AI, but analytics are often bundled under the umbrella term of artificial intelligence. There is a debate of what is analytics and what is AI, but in the end, all applied artificial intelligence is based on analytics. (Randén, 2017.)

There were many comments about using artificial intelligence in a product or application and that the laws and regulations are still so strict that for many companies this is the reason that AI is not taken into use and deployment is still in progress. Even though similar technologies are in use, they are not called artificial intelligence, but are referred to as “intelligent algorithms or

machine analysis”. This also made the inclusion and exclusion of the data more complex.

One of the challenges with this research technique was that there were many applications found on the internet and on the producer company’s websites, but there often was no information about where the application is currently used and whether it is used in Finland at all. This problem came across especially when searching for the technologies used in radiology and surgery. If there was no information about the applications use in Finland, the application was left out of the study.

There is a vast number of different kinds of chatbots used in healthcare. Especially with Covid-19, the need increased for remote healthcare services and many chatbots were created to help healthcare personnel. In this research, there was a difficulty to define and distinguish which chatbots use artificial intelligence and which are just bots based on a predefined discussion bodies. The chatbots that stayed unclear after further investigation were left out of the study.

7 CONCLUSION

The purpose of this study was to map out the different artificial intelligence applications and systems currently used in healthcare in Finland. More precisely the study explored, what kind of AI applications there are, for what are they used for, who is using them and what is the amount of applications. The aim of this study was to create an overall picture of the current situation, in order to increase understanding and knowledge of how AI is used in healthcare and how the industry can benefit from the use of AI.

Based on the results of this research it can be concluded that at the moment, artificial intelligence in healthcare is used for assisting professionals in their work, making their work more effective and efficient, supporting diagnostics, and helping patients get answers to their health problems by guiding them forward and facilitating their contact in health related matters. AI is also used for monitoring and surveillance usually with the help of a device. Artificial intelligence is often used in applications for data collection and analysis. The research also shows that there are a lot of different ways AI is planned to be used in the healthcare sector in the future. There are multiple different companies with applications under development. As the AI technologies develop further and the regulation and implementation becomes more fluent and practical, the possibilities for harnessing and utilizing artificial intelligence will be versatile and extensive.

The benefits of mapping the AI applications in one place are to increase understanding of the applications themselves and discovering the usage and the possibilities of AI usage in the healthcare sector. Understanding how and where AI is and can be used will drive the growth of wider usage and support the adoption of these technologies. Increasing knowledge about the benefits of artificial intelligence adds value to the research results. This study helps to achieve the purpose by creating an overall picture of the current situation. The list of the applications can be found in the appendices and the analysis of the usage, and the categories of the applications are in the results section. The quantitative analysis presents the amounts of the different applications and categories.

The literature review and the results of the study affirm that artificial intelligence will be an effective and supportive work partner for the healthcare professionals. There are many ways that AI will affect work assignments and the ways of doing them. As the progress and the development phase of AI for the uses of healthcare is in the beginning stages, the effectiveness, and ways of using AI will only improve and expand. At the stage AI is now it is utilized most effectively when collecting information from large data pools and analyzing it as needed. This way AI will take data and turn it into information

and the professionals can then utilize it to build knowledge for the benefit of the patients and healthcare work. Artificial intelligence will provide much needed assistance to the healthcare sector burdened by difficult circumstances such as increased sickness due to pandemics, shortages of professionals and resources, and the ever-increasing need for healthcare services as the population ages.

During the study good research practices were followed and the references and sources were used correctly according to the accepted academic writing conventions. The data collection period took almost a year and it could have continued further. In the end, there was a conclusion that enough material was found, and the study population was comprehensive. There were limitations and challenges to the study method, as was mentioned in the discussion section of the paper. Some parts of the field possibly remained hidden, for example the web pages of university hospitals did not provide information about the usage of AI and the applications used in Finland particularly in the fields of radiology and pathology. However, some material was found related to these fields as well.

The implications and contributions of this study consists of the knowledge it provides of the current situation of AI applications and of the analysis frame and method that are created for this purpose. There are different charts of the categorized applications and a table about where this information about the AI applications was found. There are not many studies done relating the subject of artificial intelligence applications in the use of healthcare in Finland. The information about these applications was very isolated and scattered around the internet. The data about the applications used in different healthcare units is mostly private and siloed. Contribution of this study is that the information about these AI applications can be found in one place. The research increases understanding and awareness of the current state and future possibilities while painting a picture of the present state of the overall usage of artificial intelligence in the healthcare field in Finland.

Many people can benefit from mapping and gathering the information about AI applications such as healthcare providers, health technology companies, researchers, administrators, teachers, students, future thesis writers and anyone who is interested in this matter. After this study, there are many possible following study subjects found for further research in this field. The subjects are presented in the next chapter 7.1 Further research.

7.1 Further research

Because of the extent and diversity of the topic, there are various possibilities for further research. This thesis has been mostly looking at the subject from the point of view of healthcare but researching and examining the applications from a technological point of view would offer another valuable perspective. There could be research done with more statistics and cluster analysis.

It could be useful to do a more detailed research of the technologies, the applications, and the companies, by interviewing the company representatives and investigating more deeply what they are doing with AI. After doing this research, it was noted that it is difficult to find all the AI applications that are used in healthcare by just searching the internet, articles, research, and web pages. AI is an up-and-coming field in healthcare, so the information about its usage is not yet freely available. To gather the information it would be worthwhile to contact and interview the people in different healthcare areas, university hospitals and companies who oversee the technologies used in healthcare. Also, Fimea and The Finnish Institute of Health and Welfare could be good sources of information. Behavioral and end-user studies from both professionals and patients of specific applications would be another useful branch of study as it could help in the development and improvement of the technology.

Because this field is developing at such a rapid pace, similar research could look a lot different in a few years. Probably then more of the information about the applications could be available online and in the companies' web pages. It would be interesting to do research on how AI is used in the healthcare of other countries and compare it to Finland. It would be also interesting to have a larger and deeper research which concentrates on what is planned and being developed for the future of artificial intelligence in healthcare.

REFERENCES

Abubakar, S., Alkassim, R. & Etikan, I. (2015). Comparision of Snowball Sampling and Sequential Sampling Technique. Biom Biostat Int J 3(1):00055. DOI:10.15406/bbij.2015.03.00055

Accenture. (2020). Keskustelevan tekoälyn rooli sosiaali- ja terveydenhuollossa. Selvitys sosiaali- ja terveysministeriön toimeksiannosta osana Hyvinvoinnin tekoäly ja robotiikka -ohjelmaa (Hyteairo). Loppuraportti. https://thl.fi/documents/10531/728886/Keskusteleva+teko%C3%A4ly_loppuraportti.pdf/5a796205-b897-0193-07fc-cb21f1cbae7c?t=1587386487503

Airaksinen, M., Gallen, A., Haataja L., Häyrinen T., Ilén E., Kivi, A., Räsänen O., Vanhatalo S. & Vijayakrishnan P. (2022). Intelligent wearable allows out-of-the-lab tracking of developing motor abilities in infants. Commun Med 2**,** 69 (2022). https://doi.org/10.1038/s43856-022-00131-6

Allot, A., Chen, Q., Leaman, R., Lu, Z., Luo, L., Wei, C. & Yan, S. (2021). Artificial Intelligence (AI) in Action: Addressing the COVID-19 Pandemic with Natural Language Processing (NLP). Annual Review of Biomedical Data Science 4 (2021). https://doi.org/10.1146/annurev-biodatasci-021821-061045

Alsina, N., Barragan J. & Molins C. (2022). NLP: Beyond numeric data in aviation. Article. https://algnewsletter.com/aviation/nlp-beyond-numeric-data-in-aviation/

Borana, J. (2016). Applications of Artificial Intelligence & Associated Technologies. Department of Electrical Engineering, Jodhpur National University. Proceeding of International Conference on Emerging Technologies in Engineering, Biomedical, Management and Science. https://www.cs.buap.mx/~aolvera/IA/2016_Applications%20of%20IA.pdf

Brandy, A-M., Byrne, G. & Doyle, L. (2009). An overview of mixed methods research. Research article, Journal of research in nursing. Volume 14, Issue 2. https://doi.org/10.1177/1744987108093962

Buczkowski, A. (2017). What's the Difference Between Artificial Intelligence, Machine Learning and Deep Learning? Blog. http://geoawesomeness.com/whats-differenceartificial-intelligence-machine-learning-d Used 28.6.2022.

Business Finland. (2020). Robotics in healthcare. Final report. https://www.businessfinland.fi/48f48c/globalassets/julkaisut/future-watch_robotics-in-healthcare-report-201211.pdf

Daws, R. (2020). AI uses data from Oura wearables to predict Covid-19 three days early. AI News. Article. https://www.artificialintelligence-news.com/2020/06/02/ai-data-oura-wearables-predict-covid19-three-days-early/ Used 4.6.2022.

Decher, D. (2021). Artificial intelligence, machine learning, deep learning – buzzwords explained. Blog. https://www.lengoo.com/blog/ai-buzzwords/ Used 1.9.2022.

Elo, S., Kääriäinen, M., Kanste, O., Pölkki, T., Utriainen, K., & Kyngäs, H. (2014). Qualitative Content Analysis: A Focus on Trustworthiness. SAGE open, 4(1), 215824401452263. https://doi.org/10.1177/2158244014522633

Fimea. (2022). Lääkinnällisen laitteen markkinoille saattaminen. Article. https://www.fimea.fi/laakinnalliset_laitteet/laakinnallisen-laitteen-markkinoille-saattaminen

Formplus. (2021). Snowball sampling guide: Types, Examples, Pros & Cons. Blog. https://www.formpl.us/blog/snowball-sampling Used 27.1.2022.

He, J., Baxter, SL., Xu, J., Xu, J., Zhou, X. & Zhang, K. (2019). The practical implementation of artificial intelligence technologies in medicine. Nat Med. 2019 Jan;25(1):30-36. doi: 10.1038/s41591-018-0307-0.

Hiltunen, L. (2009). Validiteetti ja reliabiliteetti. Graduryhmä 18.2.2009. Jyväskylän yliopisto.http://www.mit.jyu.fi/ope/kurssit/Graduryhma/PDFt/validius_ja_reliabiliteetti.pdf

Huynh, T. (2022). Deep learning vs Machine learning: What's the difference? Article. https://dev.to/tmchuynh/deep-learning-vs-machine-learning-whats-the-difference-2opf

IBM Cloud Education. (2020). What is artificial intelligence (AI)? https://www.ibm.com/cloud/learn/what-is-artificial-intelligence

Jaiprakash, A. & Crawford, R. (2016). Robots in Healthcare could lead to a Doctorless Hospital. Scientific Computing. https://www-proquest-com.lillukka.samk.fi/docview/1777522416?pq-origsite=primo&accountid=13708

Javapoint. (n.d.). Subsets of Artificial Intelligence. Article. https://www.javatpoint.com/subsets-of-ai Used 2.1.2022.

Jyväskylän yliopisto. (2010). Cross-sectional study. Koppa. https://koppa.jyu.fi/avoimet/hum/menetelmapolkuja/en/methodmap/strategies/cCross-sectional-study

Kallunki, E. (2018). Artificial intelligence can revolutionize cancer treatment - Tumors may be detected even smaller with new methods. Cancer treatments. Article. https://yle.fi/uutiset/3-10018356

Kavlakoglu, E. (2020). AI vs. Machine Learning vs. Deep Learning vs. Neural Networks: What's the Difference? Blog. https://www.ibm.com/cloud/blog/ai-vs-machine-learning-vs-deep-learning-vs-neural-networks Used 1.9.2022.

Klumpp, M., Hintze, M., Immonen, M., Ródenas-Rigla, F., Pilati, F., Aparicio-Martínez, F., ... Delgado-Gonzalo, R. (2021). Artificial Intelligence for Hospital Health Care: Application Cases and Answers to Challenges in European Hospitals. Healthcare (Basel), 9(8), 961. https://doi.org/10.3390/healthcare9080961

Knafl, K. & Whittemore R. (2005). The integrative review: updated methodology. Methodological issues in nursing research. Journal of Advanced Nursing 52(5), 546– 55. https://doi.org/10.1111/j.1365-2648.2005.03621.x

Kwork Innovaatiot. (2020). Selvitys AuroraAI-bottiteknologian vaatimuksista. Geneerinen tiedonkeruun palvelukomponentti AuroraAI-verkossa. Report. https://thl.fi/documents/10531/5914371/AuroraAI-bottiteknologian+vaatimuksia+koskeva+selvitys.pdf/16bb300e-cc8f-2df1-f73d-92878994d00c?t=1607610415927

LaRocco, S. (2022). AI is transforming disease diagnosis. Healthcare IT news. A video interview. https://www.healthcareitnews.com/video/emea/ai-transforming-disease-diagnosis Used 23.6.2022.

Lee, R. (2021). What is a decision support system in artificial intelligence (AI)? Blog. https://sisudata.com/blog/what-is-a-decision-support-system-in-artificial-intelligence Used 12.9.2022.

Lovell, T. (2022). What does the future hold for AI in healthcare? Healthcare IT news. HIMSS22 Europe, EMEA. Article. https://www.healthcareitnews.com/news/emea/what-does-future-hold-ai-healthcare

Morgenstern, J., Rosella, L., Daley, M., Schunemann, H. & Piggott, T. (2021).” AI’s Gonna Have an Impact in Society, So It Has to Have an Impact on Public Health”: a Fundamental Qualitative Descriptive Study of the Implications of Artificial Intelligence for Public Health. BMC Public Health 21(1), 40. https://doi.org/10.1186/s12889-020-10030-x

Neittaanmäki, P. & Vähäkainu, P. (2018). Tekoäly terveydenhuollossa. Informaatioteknologian tiedekunnan julkaisuja No. 45/2018. Jyväskylän yliopisto. Business Finland-hanke: Watson Health Cloud. http://urn.fi/URN:ISBN:978-951-39-7360-5

Nelson, R. (2018). "Informatics: Evolution of the Nelson Data, Information, Knowledge, and Wisdom Model: Part 1" OJIN: The Online Journal of Issues in Nursing Vol. 23, No. 3. https://doi.org/10.3912/OJIN.Vol23No03InfoCol01

Pennanen, T. (2022). Tekoälyn pullonkaulat. Article. Lääkäri lehti. https://www.laakarilehti.fi/terveydenhuolto/tekoalyn-pullonkaulat/

Phillips-Wren, G. (2012). AI tools in decision making support systems: A review. Article. International journal of artificial intelligence tools. DOI: 10.1142/S0218213012400052

Ponraj, A. (2020). Artificial intelligence – A brief introduction and history of deep learning. Article. https://devskrol.com/2020/11/07/artificial-intelligence-a-brief-introduction-and-history-of-deep-learning/

Poongodi, M., Hamdi, M., Malviya, M., Sharma, A., Dhiman, G. & Vimal, S. (2022). Diagnosis and combating COVID-19 using wearable Oura smart ring with deep learning methods. Pers Ubiquitous Comput. 2022;26(1):25-35. doi: 10.1007/s00779-021-01541-4. Epub 2021 Feb 26. Erratum in: Pers Ubiquitous Comput. 2022;26(1):37.

Randén, E. (2017). Pieni sanakirja tekoälystä. CGI. Blog. https://www.cgi.com/fi/fi/blogi/pieni-sanakirja-tekoalysta Used 10.7.2022.

Siwicki, B. (2022a). How NLP can help with at-risk patients, SDOH and pop health. Healthcare IT news, Globals edition, Artificial intelligence. Article. https://www.healthcareitnews.com/news/how-nlp-can-help-risk-patients-sdoh-and-pop-health

Siwicki, B. (2022b). Why does Big Tech often fail in healthcare? Healthcare IT news, Global edition, Cloud Computing. Article. https://www.healthcareitnews.com/news/why-does-big-tech-often-fail-healthcare

The Medical Futurist. (2021). 5 Reasons Why Artificial Intelligence Won't Replace Physicians. Article. https://medicalfuturist.com/5-reasons-artificial-intelligence-wont-replace-physicians/

Valtiovarainministeriö. (n.d.) Kansallinen tekoälyohjelma AuroraAI. https://vm.fi/tekoalyohjelma-auroraai

Väänänen, A., Haataja, K. & Toivanen, P. (2020). Survey to healthcare professionals on the practicality of AI services for healthcare [version 1; peer review: 1 approved with reservations, 2 not approved]. F1000 research, 9, 760. https://doi.org/10.12688/f1000research.23883.1

YourMD, (2022). YourMD Personal Medicine. http://your-md.com/

APPENDIX 1

The list of the AI applications

	APPLICATION	Chat	Assi	Moni	Scre	Robo	Soft	Hard	Pati	Prof	Medi	Prev	Diag
1	Milli virtual assistant	1					1		1			1	
2	Front.AI corona bot	1					1		1			1	
3	Covid-Bot, Terveystalo	1					1		1			1	
4	TerveysHelppi, CGI	1					1		1			1	
5	OuluBot	1					1		1			1	
6	Åbot	1					1		1			1	
7	Omaolo	1					1		1			1	1
8	Chatbot, Terveyskylä	1					1		1			1	
9	Chatbot, Hki	1					1		1			1	
10	Koronabotti, HUS	1					1		1			1	
11	Chatrobotti, Kymsote	1					1		1			1	
12	Kunta-Kati, v.a.	1					1		1			1	
13	Neuvo-botti, HUS	1					1		1			1	
14	NeRo-neuvolabotti	1					1		1			1	
15	TeRO-chatbot	1					1		1			1	
16	Robot assistant	1					1		1			1	
17	Helpotti-chatbot	1					1		1			1	
18	Onerva-bot	1					1		1			1	
19	Eksote- speechrobot	1					1		1			1	
20	Koronabotti, THL	1					1		1			1	
21	Clinical decision support, EBMEDS		1				1			1	1		1
22	Health benefit analysis, EBMEDS		1				1			1		1	
23	Comprehensive medication support, EBMEDS		1				1			1	1		
24	Comprehensive medication review, EBMEDS		1				1			1	1		
25	Watson health, IBM		1				1			1	1	1	1
26	Klinik healthcare		1				1		1	1	1	1	
27	Aiforia		1				1			1	1	1	1
28	Intelligent Wellbeing 360°		1				1			1	1		1
29	Omni360		1				1			1	1		1

	APPLICATION	Chat	Assi	Moni	Scre	Robo	Soft	Hard	Pati	Prof	Medi	Prev	Diag
30	Inscripta Medical		1				1			1	1		
31	Etydi, Terveystalo		1				1			1	1		1
32	Medical Suite, Bittium		1				1			1	1		1
33	Oravizio		1				1			1	1	1	1
34	ProWellness		1				1			1	1		1
35	Topcon Harmony		1				1			1	1		1
36	Digital workforce		1				1			1	1		
37	HIKARI, Fujitsu		1				1			1	1		1
38	Sholark, Fujitsu		1				1			1	1		1
39	RehabScreen		1				1			1	1	1	
40	ChildScreen		1				1		1	1	1	1	1
41	CustodyChief		1				1			1	1	1	1
42	MentalChief		1				1			1	1	1	1
43	Forsante		1				1			1	1	1	1
44	Gillie.AI			1				1		1	1	1	1
45	Awario			1				1		1		1	1
46	Verso Vision			1				1		1		1	
47	DBC solution			1			1		1	1	1		1
48	BeneCare			1				1	1	1	1	1	1
49	Cerenion C-Trend			1				1		1	1		1
50	Vesratio			1				1		1		1	1
51	BCB Medical			1			1		1	1	1	1	1
52	SkinVision			1				1	1			1	1
53	Maiju-suit			1				1		1		1	1
54	Respiro Analyst, Bittium			1				1		1	1	1	1
55	Faros, Bittium			1				1		1	1	1	1
56	Cardiac Navigator software, Bittium			1				1		1	1	1	1
57	Kipuwex			1				1	1	1	1	1	1
58	Nukute			1				1		1		1	1
59	Vitacam			1				1		1		1	1
60	SmartECG			1				1		1		1	1
61	Kaiku health			1			1		1	1	1	1	1
62	Remote monitoring, VideoVisit			1				1		1	1	1	1
63	Nightingale health			1			1		1			1	1
64	Safedo First aid cabinet							1		1	1		

	APPLICATION	Chat	Assi	Moni	Scre	Robo	Soft	Hard	Pati	Prof	Medi	Prev	Diag
65	Sensemodi							1		1		1	1
66	Optomed							1		1		1	1
67	Medtronic smart AHCL-pump							1	1	1	1		
68	Smila-medicine robot					1		1	1	1	1	1	
69	Eve-medication robot	1				1		1	1	1	1	1	
70	Vivid cardiovascular ultrasound, GE				1			1		1	1	1	1
71	MVision AI				1		1			1	1		
72	Siemens Biograph Vision 6000 + OncoFreeze AI				1		1			1	1	1	1
73	V7 Image segmentation				1		1			1	1	1	1
74	Neagen				1		1			1	1	1	1
75	Watson health, IBM		1		1		1			1	1	1	1
76	Endo-aid				1			1		1	1	1	1
77	Aiforia				1		1			1	1	1	1
78	QuPath				1		1			1	1	1	1
79	ImmunoRatio				1		1			1	1	1	1
80	BoneXpert				1		1			1	1	1	1
81	ProFound AI, iCAD				1		1			1	1	1	1
82	Eclipse, Varian				1		1			1	1		
83	Ethos, Varian				1			1		1	1	1	1
84	Da vinci, surgical robot					1		1		1	1		
	In total	21	24	20	14	3	58	26	32	62	52	64	50

Chat= Chatbots and virtual assistants, Assi= Assistance of the professionals, Moni= Monitoring & surveilling, Scre= Screening, Robo= Robotics, Soft= Software, Hard= Hardware, Pati= utilized by Patients, Prof= utilized by Professionals, Medi= Medical care, Prev= Preventive care, Diag= Diagnostics