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Artificial Intelligence Solutions in Finnish Health-Tech SMEs – Usage, Needs and Challenges

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1 Introduction

The Healthcare industry is a big field that includes sectors such as pharmaceutical sector, diagnostic services, laboratories, medical surgeries and wellbeing. Artificial intelligence (AI) aims for performing tasks that require human intelligence computationally, such as image and speech recognition. AI, especially with the great recent advances achieved by neural models, has a massive potential for transforming the healthcare and wellbeing industry; whether it is monitoring, diagnosing, or treating individuals. Furthermore, AI could provide prompt personalized and in-home assistance, reducing the workload on healthcare professionals.

Health-tech companies are at the forefront of artificial intelligence (AI) technology as they constantly innovate and develop new products and services for improving the health and wellbeing of humans, and saving lives. Due to this, governments and companies invest in the research and development of medical and health technologies, which involves staying up to date with the latest trends in AI technology and incorporating them efficiently.

An example of how AI could be used in the healthcare industry is Google's model (Nabulsi et al., 2021) for detecting abnormal chest conditions, e.g., lung cancer and presence of COVID-19, from X-ray scans. Their model achieved 95.2% sensitivity at identifying COVID-19 patients that were tested as negative but ended up exhibiting the symptoms and having a positive result within five days from the negative test. This indicates that the method was able to capture abnormalities in the X-ray despite having a negative COVID-19 test. Given that the model was not exposed to COVID-19 data, it shows that AI could be utilized to identify unseen diseases.

Finnish Health-tech companies are aware of the potential of AI, and they are investing heavily in it. However, in the healthcare sector the challenge of deploying AI is more complicated than other sectors due to the fact that the data needed for building AI solutions is more likely to include private information. Access and usage of private and personal information without consent is prohibited under the General Data Protection Regulation (GDPR) law, which is highly restricted and cannot be freely shared or used by technological companies. Another challenge for them when adapting AI solutions is possible errors (e.g., in diagnosing patients) that would be introduced by computational solutions. This puts a lot of pressure and responsibility on health-tech companies to test and validate the solution thoroughly.

The goal of this thesis is to study how Finnish healthcare companies are using AI in their operations. Based on the research, a novel threefold model of AI in business is crafted and presented. In this thesis, multiple companies operating in the healthcare and wellbeing sector, with the potential to benefit from AI tools, have been interviewed. There are companies currently trying to develop the level of AI usage, but some obstacles slow down this development, most companies have not yet fully incorporated AI in its activities. This research looks for the reasons that hinder these companies from benefiting from AI in their products or business solutions, clarifies future directions and recommendations for such businesses how to utilize AI effectively in their activities.

The main contributions of this research are:

- Interview different small and medium-sized enterprises (SMEs) that deal with healthcare and wellbeing, to get their opinions and insights about the needs to adopt AI and the challenges they face in using it.
- Conduct a qualitative analysis on the research results and formation of a general view on the level of maturity for using AI in Finland among the SMEs.
- Creation of a new threefold model of AI in business.
- Propose recommendations that such companies could follow to utilize AI in their solutions.

1.1 The commissioner

Transparency about the funding and the commissioner is a crucial part for research ethics(Krimsky, 2010). This section describes the project that funded this research and the commissioner that is in charge of the project.

This research has been conducted as part of the AI BOOST project (Alnajjar et al., 2022; see also Tikkanen et al., 2022) in Kajaani University of Applied Sciences. The goal of this project is to produce new information and understanding of how businesses in Finland are using AI, and to clarify the elements that encourage and impediment the adoption of AI by small and medium-sized businesses. Another objective of the project is to understand how SMEs can use AI to innovate, grow their current businesses, and improve operational productivity. Ascertaining how businesses'

strategies, revenues, and outcomes may be impacted by the use of AI in the context of SMEs is also an aim. In this thesis, all these topics, except the last one, are studied in the case of Finnish SMEs in the healthcare sector. The consideration of strategies and revenues is left out for future work, given the scope of the thesis.

The AI BOOST project is under the CEMIS Business Development (CBD). CEMIS refers to (Centre of Measurement and Information Systems), the Universities of Oulu and Jyväskylä, the Kajaani University of Applied Sciences, the VTT Technical Research Centre of Finland Ltd., and the CSC - IT Centre for Science Ltd. collaborate under a contract to form the CEMIS. By offering research and development services and university education in a cutting-edge and global environment, CBD aims to generate excellent specialists, cutting-edge technologies, and innovative business opportunities for companies involved in the development and use of measurement and information systems. Students seeking careers as experts can benefit from CBD's stimulating educational environment, and professionals looking to advance their careers can work in an innovative, global environment.

A recent initiative, Arctic Data Intelligence and Supercomputing Ecosystem in Kainuu (AIKA), creates an ecosystem to assist businesses with the application of high-performance computing and artificial intelligence. In addition to the educational opportunities AIKA provides, the ecosystem combines powerful expertise in various technological fields such as measurement technology, 3D, virtual reality, and augmented reality technologies, data analytics, and artificial intelligence. With expertise in these technologies and access to high-performance computing environments, AIKA facilitates local businesses by assessing their maturity level of the use of digital technologies and data, and supporting their AI use cases through guidance and high-performance computing capabilities.

The work conducted in this thesis aligns greatly with the motives and goals of AI BOOST, CEMIS and AIKA. It does so by taking a deeper look into a specific and important sector, i.e., healthcare and wellbeing, and analyses their AI needs, challenges and potential utilizations to foster their services and products.

1.2 Preliminaries

This section introduces preliminary concepts in more detail to clearly define what is meant by them in the scope of this work. This section, however, does not cover all the concepts mentioned in the thesis as some of them are defined in their corresponding sections.

Small and medium-sized enterprises (SMEs): The term SMEs used frequently in this research, and, therefore, it is of a great importance to understand what is meant by it in concrete. To define SMEs, this research follows the definition proposed by the European Union, which considers SMEs as independent companies whose number of employees does not exceed 249 workers, and whose annual turnover is less than 50 million euros (OECD, 2005). Hence, any company matching these criteria is considered as an SME in this thesis.

Healthcare technology (i.e., health-tech): Any technology and technological innovation (e.g., medical devices, telemedicine, health information systems, electronic health records, algorithms, artificial intelligence, cloud or blockchain) that is employed to improve the quality of lives or enhance healthcare services, its delivery and outcomes, along with solving any problems that relate to healthcare efficiently. As such, health-tech companies are those companies concerned with such healthcare technologies.

Artificial Intelligence (AI): AI is a rather old concept (introduced initially in 1959 at Dartmouth College by John McCarthy), and it's meaning constantly evolves as technologies advance more and more every day. The general meaning it has, as the name indicates, is "making machines do things that would require intelligence if done by men" (Minsky, 1982). A recent definition is the one proposed by the European Union Commission's Communication on AI (2019), which defines AI as "systems that display intelligent behaviour by analysing their environment and taking actions – with some degree of autonomy – to achieve specific goals." Although the concept has been around for more than half a century, there is a concrete definition of what is artificial intelligence as there are many ways that AI can mimic human activities, learn, and work independently (Al Natsheh et al., 2021). AI also includes various forms of systems; for instance, they may be software only or embedded software in hardware devices.

In the past, AI was often used to refer to rule- and statistical-based systems, while currently it is commonly used to refer to machine learning and deep learning. All of these are, in fact, subfields of AI. Furthermore, there are numerous intelligence tasks that AI aims to tackle such as financial analysis, object recognition and natural language processing, whether it is understanding or

generation. Each of these tasks branches further into more focused tasks. For example, natural language processing includes, but is not limited to, sentiment analysis (knowing whether a given sentence is positive, neutral or negative), semantic similarity and clustering (grouping documents and sentences that are alike), and creative generation of news and poems (Hämäläinen & Alnajjar, 2021b). This thesis considers computational solutions that fit any of the above definitions as AI solutions, regardless of the complexity of the approach itself.

AI Maturity: The level of development and efficacy of a company's artificial intelligence capabilities. It entails assessing the effectiveness of an organization's use of AI to achieve its objectives, the degree to which AI has been incorporated into its operational procedures, and the caliber of the data used to feed the AI algorithms. On a scale from low to high, the maturity level is typically evaluated and takes into account variables including data availability and quality, technological infrastructure, human resources, level of knowledge, governance, and ethical concerns. The more developed and potent a firm's AI capabilities are anticipated to be, the more mature the company is.

1.3 Motivation

Businesses in a variety of industries are increasingly using artificial intelligence (AI) as a tool to boost production and efficiency. AI may be very helpful to businesses by automating tasks that formerly needed human resources. Also, a core gain of using AI is the ability to analyse data at a level that no human can match, given its ability to perform bulk analysis rapidly. These capabilities of AI can bring significant benefits to companies, despite the field the company is in. Due to these reasons, companies are investing heavily in data science (extracting, analysing and modelling data to predict behaviours and upcoming events).

Through data science, companies gain a deeper understanding of their customers and their interactions and usages with the services provided by them via data-driven solutions. With data analytics, management can make decisions that are backed up by numbers and statistics, making them more reliable and accurate. Nonetheless, to employ data science and AI efficiently, multiple factors are required to be present, such as the ability to access computational resources for storing and analysing the data (e.g., via cloud solutions) in an affordable way.

Some of the challenges that the healthcare and well-being sector in Finland face are an aging population, an increase in chronic diseases, and rising healthcare costs. Due to these difficulties,

healthcare providers, including SMEs, are under pressure to come up with creative, affordable solutions to enhance patient outcomes and fulfil the rising demand for healthcare services. By giving healthcare professionals access to real-time data analytics, predictive modelling, and individualized treatment plans, AI has the ability to address these issues.

In Finland, 99.1% of businesses are SMEs, and 16% of them use AI technologies, which is twice the rate of enterprises using AI in Europe as a whole (OECD, 2019; Eurostat, 2021). The healthcare industry in general has been lagging in the adoption of AI, despite the potential advantages it provides, compared to other sectors such as media or finance, which is probably due to the sensitive nature of patient data and the reluctance to share it, or the lack of integration of AI training for healthcare personnel.

The numerous benefits that AI offers and the lack of its integration in Finnish health-tech SMEs is the true motivation for this thesis. Through the research, it aims to first understand the AI needs of these enterprises and where they stand in terms of AI utilization. Following that, it will investigate the difficulties and challenges of incorporating AI in Finnish health-tech SMEs to identify the factors that hinder embracing AI. Then, in this thesis, it will draw an overall picture of AI maturity in the healthcare sector in Finland based on the results of the qualitative interviews, and will discuss some potential solutions to overcome the obstacles that prevent utilizing AI in Finnish healthcare SMEs.

1.4 Research questions and methodology

The objective of this research is to develop the understanding of integrating AI into the healthcare and well-being business environment in Finland. This helps to know what are the current and future needs of Finnish SMEs to efficiently utilize AI and increase their competitive edge compared to the world healthcare sector. Many articles and research papers have highlighted the potential and efficacy of AI applications for healthcare SMEs. Hence, this research aims to study the health-tech SMEs and analyse their use-cases to answer the following research questions:

RQ1. What is the level of AI utilization by Finnish health-tech SMEs?

RQ2. What are the challenges Finnish health-tech SMEs face in adopting AI solutions?

RQ3. What kind of services Finnish SMEs need to support them in developing and adopting AI solutions in their business activities?

RQ4. How can Finnish companies having different levels of AI maturity support and help each other to achieve efficient AI utilization?

To address these research questions, data must be collected from companies operating in the healthcare and well-being sector, and their responses and opinions analysed. Conducting interviews with high-level company representatives is one of the most effective methods of gathering valid and reliable data relevant to these research questions. Through these interviews, we can gain comprehensive insights into the current position of Finnish health-tech SMEs, the challenges they face, and how they can best utilize AI.

To accomplish these research goals, a qualitative interview approach was chosen as the research method. Qualitative research techniques are particularly useful in deeply examining a specific phenomenon in its natural setting (see Zegeye et al., 2009). This approach is particularly valuable in acquiring an in-depth understanding of complex phenomena, such as the application of AI in the Finnish health-tech industry. The data collected through these interviews can be analysed to identify common patterns, trends, and challenges in AI utilization in this field. The qualitative approach is particularly appropriate for this study as only a few firms were interviewed.

The findings of this research will provide valuable insights into the current use, needs, and challenges of AI integration among Finnish health-tech SMEs, and will enable us to develop a service portfolio to facilitate the efficient adoption and use of AI.

1.5 Research structure

This thesis is structured into seven major sections. In the first section, the introduction, the thesis is introduced along with the essential concepts and an overview of the commissioner. Additionally, it explains the rationale for the topic selection of the thesis as well as the research questions and methods.

The literature review, which is the second section, provides a summary of the development of AI in healthcare over time, its current applications in the field of health technology, and the difficulties in implementing AI. The influence of AI on the healthcare sector and the development stages of AI applications are also covered in this section.

The research strategy and data gathering techniques performed in the thesis are explained in the third section, which is titled “Methodology and Data”.

The findings of this research, which observe the use and effects of AI in the health-tech industry, are presented in the fourth section. The findings cover a variety of topics, such as the perceived maturity level of AI, various AI application domains, computing environments, and expected benefits of AI, among other factors.

A brand-new framework for analysing AI's use in business is presented in the fifth section. It consists of three categories: AI curious, AI embracing, and AI catering. This section also explores inter-categorical business opportunities associated with AI adoption.

The sixth section, the discussion, examines the challenges associated with AI maturity and adoption, the applications of AI in the health-tech sector, and the impact of AI in the healthcare industry.

Finally, the thesis concludes with a summary of the main findings and contributions of the study. The conclusion section provides insights into the current state of AI adoption in the health-tech sector and offers recommendations for future research in the field.

2 Literature Review

In recent years, artificial intelligence (AI) has significantly impacted various industries, and the health-being industry is not an exception. Reddy, Fox, and Purohit (2019) explored the incorporation of AI in healthcare delivery, identifying challenges and opportunities for large-scale use while addressing issues such as medical responsibilities and data access. They utilized a qualitative method based on observations of existing AI technologies and predictions of future developments.

In another research, Garbuio and Lin (2019) analysed the complexity of value-users in healthcare and emerging business models in AI-driven healthcare startups. By examining archetypes of business models used by entrepreneurs worldwide, they conducted a quantitative analysis of 30 healthcare startups that deploy AI. They concluded that designing effective business models is crucial for bringing beneficial technologies to the market.

AI definitions and deployment status for medium-sized companies were investigated by Ulrich and Frank (2021), particularly German SMEs, and the opportunities of AI in supply chain optimization. They collected both quantitative and qualitative data through an open and closed survey questionnaire from 12,360 German companies' emails via the Nexis database. Their findings highlighted the relevance of technologies for companies, AI opportunities in SMEs, and barriers to AI adoption.

The research conducted by (Bettoni et al., 2021) focused on the challenges of applying AI in companies and AI maturity models. They conducted face-to-face interviews and reviewed state-of-the-art literature, examining two SMEs in Poland and Italy. Their research resulted in a conceptual framework to support AI adoption in SMEs.

Bunte et al., (2021) studied the application of AI in manufacturing and its utilization in the industrial environment, particularly in measuring the financial impact of AI. They employed a mixed-methods approach, using open-ended online questionnaires to collect data from 441 participants across 68 companies in Germany, Austria, and Switzerland. Their research suggested potential strategies to support AI usage in SMEs and identified two best practice solutions.

AI's potential for healthcare solutions, the challenges involved, and the perspectives of different stakeholders on AI implementation was explored in the research presented by Petersson et al., (2021). Using a qualitative method with an inductive approach, they conducted individual, semi-

structured interviews with 26 healthcare leaders. They identified three types of challenges linked to AI implementation in healthcare.

Aung et al., (2021) reviewed AI's current applications in healthcare, including its benefits, limitations, and future scope. They conducted a qualitative literature review, searching for terms such as AI, machine learning, deep learning, healthcare, and medicine in PubMED and Google Scholar from 2000 to 2021. Their research suggested that AI could alleviate the workload for healthcare professionals, reduce errors, and increase precision, thereby improving the overall quality of work.

Real-world AI applications in healthcare and the opportunities they present were examined through an extensive literature review and analysis of diverse real-world cases (Lee & Yoon, 2021). In their work, they collected secondary data to identify approaches to better manage AI applications in healthcare. Additionally, they discussed considerations to enhance AI utilization and patients' confidence in the healthcare system.

In summary, the literature reveals that AI has the potential to significantly transform healthcare and other industries, with challenges and opportunities arising from its implementation. Key areas of focus include the design of effective business models, AI adoption in SMEs, supply chain optimization, and the financial impact of AI in manufacturing. The application of AI in healthcare has the potential to enhance patient outcomes, lighten the strain of medical staff, and boost productivity. However, challenges such as medical responsibilities, data access, and stakeholder perspectives need to be addressed to ensure successful implementation. By understanding and overcoming these challenges, AI can continue to revolutionize industries and provide innovative solutions to various problems.

2.1 An overview of AI history in general and in healthcare

It is necessary to understand the journey of using artificial intelligence, how it began, what stages it went through with all its ups and downs, and what challenges associated with it previously, to help us know the nature of the AI challenges to overcome the current difficulties and better predict the future of this technology.

At first, one may think AI is a modern concept, but in fact, it is not. The first programmable digital computer was invented in the 1940's by Alan Turing, and he raised the core question of “Can a

machine think?". Soon after, in 1956, four scientists, John McCarthy, Marvin Lee Minsky, Nathaniel Rochester, and Claude Shannon proposed a research project to Dartmouth College to prove that a machine can learn and mimic human intelligence. This famous Dartmouth conference was the first breakthrough for AI science. McCarthy defined AI as "the science and engineering of making intelligent machines" (Toosi et al., 2021).

Since then, the journey of AI has begun, and it has faced two stagnant periods that some sources called "the AI winters" in contrast to the periods of prosperity and recovery of AI that have been called "the AI summers". The first AI summer started immediately after the Dartmouth conference. Scientists' enthusiasm for this revolutionary innovation prompted them to invent and develop several AI systems. Due to computing processes and memory limitations, the summer didn't last long, it was the obstacle to the success and growth of AI systems, hence AI reputation began to decline and with it the first AI winter began. Both AI winters spanned about six years, the first started in 1973, and the second in 1987.

In 1980, the interest in AI renewed and received significant funding from both government and private sectors. Especially that experts developed "neural networks", which are structured on connectivity models that mimic the human brain neurons. These hopes did not last long, and soon the second winter took over. The high expectations from public and media met with unsatisfactory results by experts in the field, which caused a significant cut in funding for AI research. These unsatisfactory experts' outcomes were due to the false approach in designing the machine solving-problems logic, as it was built to follow the same steps as humans think. As they designed problem-solving systems that follow the same approach as the human way of thinking to solve problems. Also, the machines were trained to solve simple problems, but when trying to perform AI in real life problems which are complicated, the machine was unable to solve them.

In the mid-1990s, the AI boom was making its way back on track. This is because of two driving forces, the availability of large real-life datasets and the hidden Markov models (HMM) which are based on statistics and mathematics. As a result, for the first time in history, in 1997, an AI system proved its efficiency over human intelligence. For instance, a system developed by IBM, called "Deep Blue" was able to beat the best maestro chess world champion in chess. Since then and till this moment, AI has witnessed only more development and is used in almost all different fields. It has the potential to transform many of the routine tasks into automated processes, which will change the character of many professions and lead to the demise of some of them permanently.

The earliest initiatives to apply AI to healthcare date back to the 1960s, with an emphasis on developing decision-support tools for medical practitioners. (Kulikowski, 1987). One such example is MYCIN, developed in the 1970s at Stanford University, which was designed to diagnose and recommend treatments for bacterial infections (Shortliffe, 2012). Despite its limitations, MYCIN illustrated AI's potential in the medical field. Throughout the 1980s and 1990s, researchers continued to explore AI applications in healthcare, developing expert systems and knowledge-based tools for diagnosis and treatment planning (Fox et al., 2000). During this time, artificial neural networks (ANNs) emerged as a promising approach for medical image analysis and pattern recognition, laying the groundwork for more advanced techniques (Dreiseitl & Ohno-Machado, 2002).

The usage of AI in healthcare has increased as a result of the advancement of machine learning (ML) and deep learning (DL) in recent years. For instance, Google's DeepMind developed an AI system capable of diagnosing diabetic retinopathy and macular degeneration from retinal scans with remarkable accuracy, rivalling human specialists (Gulshan et al., 2016). Another example is IBM Watson, which demonstrated the ability to identify novel treatment options for cancer patients by analysing vast amounts of medical literature (Somashekhar et al., 2018). Moreover, AI has shown promise in predicting disease outbreaks and public health crises, as evidenced by BlueDot's early detection of the COVID-19 outbreak (Bogoch et al., 2020).

Furthermore, AI-driven models, such as Google's model for detecting abnormal chest conditions like lung cancer and COVID-19 presence in X-ray scans, have demonstrated high sensitivity rates in identifying previously unseen diseases (Nabulsi et al., 2021). Telemedicine and virtual healthcare have also benefited from AI advancements, with chatbots and virtual assistants providing patients with personalized healthcare advice (Miner et al., 2016). Additionally, AI-powered wearable devices and mobile apps have facilitated remote patient monitoring, improving disease management and preventive care (Steinhubl et al., 2015).

As a summary, the history of AI in healthcare spans several decades, beginning with early decision-making support tools and evolving into sophisticated machine learning and deep learning applications. Medical imaging, diagnosis, treatment planning, and public health are just a few of the domains where AI has proven to be quite useful. AI is expected to become increasingly crucial in the future of healthcare as technology advances.

2.2 Current AI uses in health-tech sector

Healthcare organizations are rapidly evolving due to the implementation of artificial intelligence (AI) systems in administrative and medical processes. AI has been particularly influential in early detection and diagnosis, and has been shown to improve service quality in the healthcare sector.

In recent times and over the years deep learning machines, applications of natural language processing and robotics have been developed tremendously in the science of AI. These are used in various activities in the healthcare sector to improve the quality of care provided and free up more time for doctors and health workers (Garbuio & Lin, 2019). Some concrete examples can be mentioned such as image detection techniques for tumour detection (Kapoor & Thakur, 2017), fracture detection (Anu & Raman, 2015) and cataract detection (Jindal et al., 2019), text analysis methods such as depression detection (Hämäläinen et al., 2021) and symptom analysis (Dreisbach et al., 2019), and signal processing methods such as EEG (Hosseini et al., 2021) and ECG signals (Roopa & Harish, 2017).

According to Becker (2019) the most benefiting healthcare use-cases of AI applications are: 1) measuring the risk of disease and predicting success rate of treatment before starting the treatment. 2) reduce or address complications. 3) monitoring and supporting patient care during the operations or treatment phase. 4) in pathology science for exploring new treatments for a specific disease or searching for an optimal treatment for new diseases.

There are many factors that led to the decline in the AI implementation by physicians and the level of health services, due to the shortage of manpower, changes in demographics and administrative requirements, while faced by an increase in the rate of diseases and information technology demand, this resulted in changes in expectations. However, it is predicted in coming years that AI technologies will take over some of the tasks of doctors and health care providers, and there are some beliefs that robots could replace surgeons (Reddy et al., 2019).

Ali et al., (2023) conducted a more recent study survey on academic articles on AI applications in healthcare, narrowing down from 1,988 to 180 articles for thorough analysis. The classification framework focuses on four dimensions: AI-enabled benefits, challenges, methodologies, and functionalities. AI consistently outperforms humans in accuracy, efficiency, and timeliness in both medical and administrative tasks. AI's contributions in diagnosis, treatment, consultation, and health monitoring help enhance patient outcomes, particularly for chronic conditions. They

suggested that more exploration of value-added healthcare services, patient data security and privacy, health monitoring features, and innovative AI-driven IT service delivery models is needed.

2.3 AI impact

All the healthcare workforce is impacted by the applications of AI, and the effects of AI on the medical sector can be summarized in the following four approaches: relieve, split up, replace, and augment. Relieving by facilitating clerking duties, assisting use of information technology, synthesis and summary of patient record, and screening in scan interpretation. Splitting up by providing medical advice, circumventing unnecessary admissions through early screening and diagnosis, and tailoring chronic disease management. Replacing administrative jobs of physicians and nurses and streamlining physician focus to patient interaction. Augmenting such as improving quantitative precision, reducing medical error or unconscious bias, or providing up-to-date guidance (Eggers et al., 2017).

The impact of AI on the healthcare industry has been enormous and diverse. Healthcare organizations are increasingly utilizing AI technologies to enhance efficiency and productivity, reduce costs, and improve patient outcomes (Kim et al., 2022). AI-enabled technologies can provide healthcare providers with more accurate diagnoses, improved test and scan accuracy, and personalized care for patients (Gulshan et al., 2016). By analysing vast amounts of data, AI can help clinicians make more informed decisions, and it can also provide real-time patient data and identify high-risk patients who require intensive interventions(Lamba et al., 2021). Moreover, AI can help healthcare organizations manage resources more effectively by predicting patient demand and improving inventory management (Murali & Sivakumaran, 2018).

Despite the potential benefits, implementing AI in healthcare presents significant challenges, including concerns over patient data privacy and security and ethical considerations about AI's use in decision-making (Secinaro et al., 2021). Moreover, the use of AI may perpetuate biases present in the data used to train AI models, exacerbating existing health disparities (Jiang et al., 2017). New approaches have been proposed to build artificial intelligence algorithms that contribute to addressing health services management issues to reduce waiting time and obtain more efficiency for services such as supporting clinic appointment scheduling and patient prioritization. AI techniques allow predicting the length of stay of patients before they are admitted to the hospital, so provides more efficient management and use of hospital resources. As for the time doctors spend

gathering clinical notes on patients' situations, AI technologies such as natural language processing (NLP) has been utilized to capture voice, analyse it, and convert it to documented records in different formats, which allows doctors to care for more patients (Aung et al., 2021).

AI has the ability to completely transform healthcare, and healthcare organizations that successfully integrate AI technologies can expect major benefits such as increased efficiency, better patient outcomes, and lower costs (Kim et al., 2022). To ensure that AI is integrated responsibly and ethically into the healthcare system, healthcare organizations must prioritize investment in AI and work closely with technology partners (Topol, 2019).

2.4 AI challenges

One of the main challenges in AI is that it is often oversold as the silver bullet that solves every problem with a high accuracy. Even academic research papers fall for exaggerating how well their new AI models work in reality. For instance, a recent survey (Hämäläinen & Alnajjar, 2021a) found that none of the surveyed papers made any clear effort in justifying the methods that were used to evaluate the performance of the proposed models, and worse yet, all of the papers based their assessment on the performance on extremely small sample sizes. In addition to this, a gap has been perceived between machine learning models in research and how well they actually try to tackle the real-world problem they are meant to solve (Hämäläinen & Alnajjar, 2021c). This means that often AI models are not quite as powerful and production ready as the current research might suggest.

It is complicated to provide advanced healthcare in many countries due to limited capabilities of healthcare infrastructure, resources constraints and administrative burdens. The tools of AI and information technology came to contribute from reducing the burden of managing health services to allow more clinical care and reduce pressure on doctors. The rapid progress in AI serves the health services in terms of alleviating administrative and resource challenges, but so far, the full maturity of the applications of AI in the sector has not yet been achieved. (Reddy et al., 2019). Many governments have adopted AI in different disciplines and activities, while some governments have included themselves in the activities of AI applications in the health sector. Recently due to the success of artificial intelligence in the medical field, governments may be required to develop a strategic plan to determine how artificial intelligence is applied in the field of healthcare and administration, and funders will be established for this process (CIO, 2018).

Permission and accessibility to patient data is critical and important for improving and training AI algorithms. AI developers have shown the difficulty they face in health services sharing their patient data. This indicates the need for cooperation from patients and patient representatives, not just doctors and specialists, to develop appropriate protocols to ensure that a quality service that suits all parties is designed with the uses of personal data (Powles & Hodson, 2017).

Integrating AI applications into clinical care will meet resistance from clinicians. Clinicians have always been slow to embrace new technology, and they are more reliant on proven-tested methods. Relevant channels must be regulated to pave the way for these uses of AI in medical care. It is essential for authorities and AI developers to involve clinicians in the trials and testing of these applications, not only to build trust in the applications among clinicians, but also to ensure that these applications are practical in a way that does not add a burden to the healthcare workforce. In addition, it will allow the design of user-friendly applications and interfaces that ease the integration with existing health technology systems (Heston & Heston, 2018).

2.5 AI maturity levels

Maturity models (MMs) are a set of measurement tools that can evaluate organizations against specific criteria to understand their degree of capability in certain domains. The concept of MMs was initiated by Gibson and Nolan during the 1970s, and soon after, many models were developed in various fields and been used widely. MMs has proven its effectiveness in measuring the industry 4.0 revolution processes and its development, as many technology and management sectors have used MMs extensively to pursue and develop their organizations' capabilities in the field (Alsheiabni et al., 2019).

A company's ability to build real-world successful AI applications depends on its AI maturity level. There are many models for evaluating the AI maturity level of a business. For instance, Gartner published, in (2019), an AI maturity model that divides companies regarding its use of AI into five levels presented in Figure 1., which consists of:

1. Awareness: in this level, the organization talks about AI and its advances and potential benefits that it would gain by employing AI in their operations, without taking any proactive actions to test its usability for their needs. This stage brings with it the risk of overhyping AI and the degree to which it could contribute to the business.

2. Active: the organization here runs some experiments and develops proof of concepts of AI solutions, for instance to analyse their data to acquire interesting insights and knowledge about their users and behaviours.

3. Operational: when AI and machine learning are used in a company on a regular basis and production level, they are considered to be at the operational level. Hence, to reach this level, AI models should support the company and provide clear values to its business, and the company should have dedicated allocations of resources (e.g., financial, human and computational) for AI solutions.

4. Systemic: incorporating AI models in nearly, if not, all of the upcoming digital projects, and using them pervasively in current ones places the organization at this level. These projects would communicate effectively across each other to facilitate business operations.

5. Transformational: as Gartner phrases it, this level is when the "AI is part of business DNA". In other words, the core services that the company offers rely heavily on AI, such as the solutions provided by Google that integrate AI in various aspects (e.g., search engines, advertisements, and recommendations).

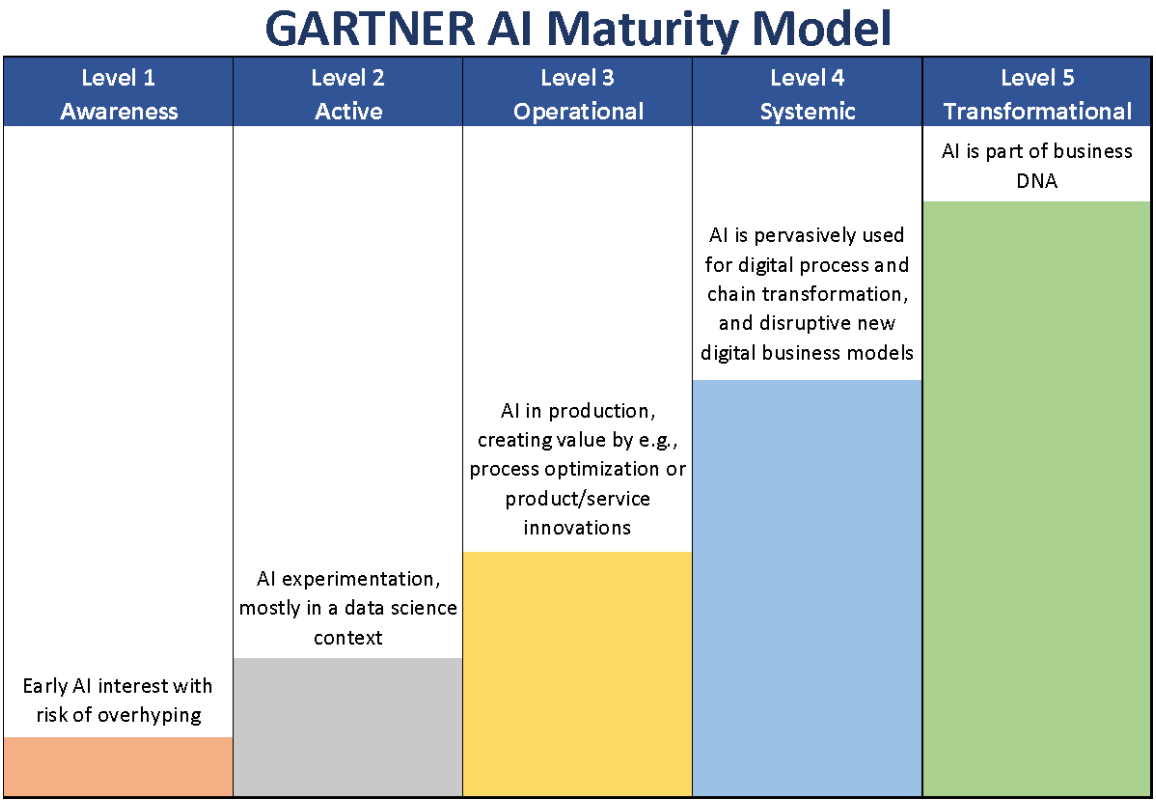

Figure 1: Gartner's AI maturity model, 2019.

Other models include that of Microsoft, ElementAI and IBM. Microsoft's AI maturity model has four levels and are defined as 1) foundational, 2) approaching, 3) aspirational, and 4) mature. (Charran & Sweetman, n.d.).

In the foundational level, the company attempts to obtain a better understanding of what AI is and where would AI be applicable in their business. The main difference between this level and the first level of Gartner's is that companies can adopt AI solutions, which are often provided by AI-specialized companies.

The second level, approaching, includes companies that seek to reach business decisions by following data-driven strategies and approaches. They would also pursue AI-based approaches to disrupt the industry and gain a business advantage, and continuously invest in acquainting themselves with ways to implement, monitor and enhance their AI usability.

Aspirational companies know the power that AI provides them to compete with other companies in the industry and transform their operations. Additionally, they understand that competitors utilize AI in their businesses. At this level, companies often make use of standard AI solutions

provided by service providers, but they are encouraged to experiment and build their own AI models to acquire results that are unique and tailored to their needs.

The final level of Microsoft's AI maturity model, the mature level, talks about companies that sit at the highest level of understanding regarding AI solutions, along with their applicabilities, benefits, risks and concerns. While AI-mature companies regularly develop innovative AI approaches, they aim to employ them where positive impacts are expected. Mature companies maintain a steady level of monitoring, improving, and implementing AI solutions, and actively hire outstanding AI talents. But, at the same time, they question using AI where ethical concerns rise, which is because they deeply understand what AI is good at and what its limits are.

ElementAI published a white paper where they described their AI maturity framework. The framework has five stages of maturity, which are 1) exploring, 2) experimenting, 3) formalizing, 4) optimizing, and 5) transforming. In addition to these five stages, the framework considers five dimensions of enterprise AI. These dimensions are 1) strategy, 2) data, 3) technology, 4) people and 5) governance. The dimensions represent different aspects that require maturity to achieve a higher AI-maturity level. (Eggers et al., 2017).

The stages of maturity proposed by ElementAI are similar to those of Gartner's. In the exploring stage, the company is curious about AI and what it can bring. The next stage, experimenting, is where Proof of Concepts are built to test AI solutions and their applicabilities. Following that, the company moves the solutions to production in the formalizing stage. Once the solutions are in use, the company fine-tunes and optimizes them to increase their efficiency in the subsequent stage. During the optimization stage, the company also scales the number of in-production AI solutions. Transforming, the final stage, occurs when the company employs AI in many important sides of its business.

Regarding the five dimensions, strategy is where the planning for what, when and how to incorporate AI in the business takes place. The goal of the plan should align with the desired maturity level. After constructing a concrete and actionable plan, the company needs to collect the necessary data for its AI strategy. The third dimension revolves around the technological resources from models and tools to infrastructures that the company needs to develop and manage their AI. The fourth dimension, i.e., people, covers who are the people who will be involved in the process of building and deploying AI solutions, what are their roles and skills, and how will their performance be assessed. Governance, the last dimension, refers to the policies, processes,

procedures and technologies that will be followed to ensure creating AI solutions that are reliable, safe and trustworthy.

The AI maturity framework introduced by (IBM, 2021) outlines seven dimensions to evaluate the success of a certain AI solution. These dimensions are a) impact on the business, b) value to the end client, c) technology sophistication, d) trustworthiness, e) ease of use, f) AI operating model and g) data. Each of these dimensions have sub-criteria that address what should be considered when evaluating the dimension. For example, the impact on the business is divided into two criteria, which are business impact (the percentage of revenue that this AI affects) and portfolio impact (the increase in offering and broader portfolio). In addition to the seven dimensions, the framework has three ranked status levels, which are 1) silver, 2) gold, and 3) platinum. The higher the rank, the higher maturity level of the AI solution. The final status level for a dimension is defined as the aggregated value of its sub-criteria. Given the scope of this thesis, the details of each dimension, its sub-criteria and the description of what each status corresponds to in that context are left out.

Measuring AI maturity of a company is crucial to understand what is its current level of utilization of AI, what is the impact of AI on the business and society, and how it could improve its current maturity level. For this reason, Teknologian tutkimuskeskus (VTT) Oy with collaboration with Finland's Artificial Intelligence Accelerator (FAIA) created a tool that allows companies to measure their current AI maturity and where do they stand in comparison to other companies in the market. VTT's AI maturity tool evaluates the organization's level of AI maturity on six dimensions, namely 1) strategy and management, 2) products and services, 3) competence and cooperation, 4) processes, 5) data and 6) technology.

In this thesis, small and medium-sized enterprises that work on healthcare and wellbeing were evaluated using Gartner's model. This is because Gartner's AI maturity model provides a simple, yet clear, way of determining the current company's position in terms of AI utilization. IBM's and ElementAI's frameworks are more detailed but could appear as complex and overwhelming at first. Furthermore, IBM's framework concentrates on a certain AI solution, rather than the overall employment of AI in the organization; hence, these frameworks will not be considered in the interviews.

3 Methodology and Data

This section explains the research strategy and data collection methods used that enable us to answer the research questions. This Master's thesis employed a case study research strategy, focusing on health-tech companies in Finland as the unit of analysis. The case study methodology allows to explore complex phenomena and gain insights into the underlying dynamics and mechanisms that drive them (Yin, 2009). Through semi-structured interviews (Saunders et al., 2009), rich and detailed data from various stakeholders can be collected within the health-tech industry.

To apply the case study methodology in this research, first, a literature review conducted to identify relevant theories and concepts that would inform the research questions Then, collected data through semi-structured interviews methods. The data were analysed using a qualitative data analysis software, following a systematic approach. The results of the analysis informed discussions and recommendations for further research and practice.

The research process can be depicted as follows:

1. Definition of the research problem and objectives
2. Review of relevant literature and development of the theoretical framework
3. Selection of the case study research strategy
4. Data collection
5. Data analysis using ATLAS.TI
6. Identification of themes and subthemes
7. Development of a conceptual framework
8. Discussion of the findings and their implications
9. Recommendations for further research and practice

The research methodology consists of qualitative approaches, that will include four parts, the first is researching the existing healthcare and wellbeing SMEs in Finland, to analyse their products and services offerings to build general understanding about health-technology applications in the market. Then, in the second phase, the companies that have digital products or services have

been contacted to request interviews with them. The third part involves analysing the findings from the conducted interviews with health-tech Finnish companies about their AI usage level with a focus on Small- and Medium-sized Enterprises (SMEs), in which business areas its used, what are the main obstacles they face in their use of AI, and what are their current and future needs to ease the process of adopting and using AI? Finally, the development section which will provide insights and recommendations to support the use of AI in the Finnish health-tech businesses, based on the interviews conducted, and an overview of the future possible uses of AI in the sector.

3.1 Identification of interview participants

Names and additional data of companies in Finland operating in the healthcare and wellbeing sector were collected and sorted according to selected criteria. Business Finland and LinkedIn databases were used to search and find companies that match the criteria declared above. The choice of these services is motivated by the coverage and efficiency of their search feature to look for and discover businesses according to the sector they operate in. Furthermore, both databases are concerned with the business world; hence, they are able to provide more recent results. Based on Business Finland's portal (Business Finland, n.d.), accessed in June 2022, 345 companies work on health and wellbeing in Finland. As for LinkedIn, the search results showed about 700 companies that work in the hospital and healthcare and/or medical device sectors in Finland with company size ranges from one to two hundred employees. The names of these companies and relevant data such as (website address, products, services, location, and contact details) have been composed in an excel sheet to facilitate categorizing, filtering and annotating them. The following steps focused on clustering the companies into two groups based on the applicability of applying digital and AI solutions in healthcare context to their products or services.

The first group included companies that can utilize digital and AI solutions. Examples of these companies are companies that provide wearable devices which collects data about the patient such as heartbeats, number of steps, blood sugar, respiratory rate, companies that provide medical imaging devices, or those that provide medical diagnostic and analysis services such as examination of laboratories samples, x-ray image analysis, ECG or EEG readings analysis, and so on.

Companies that have a weak chance for applying digital and AI solutions in the healthcare context are placed in the other group. The group consisted of companies that, for instance, sell medical consumables (masks, gloves, syringes, etc.), offer medical furniture, provide medical training or

consultation services, and distribute medical goods to other suppliers. Certainly, there are endless opportunities for all companies to benefit from AI, whether in customer service, sales and marketing management, or the company's logistics management, but since this study focuses on AI as a tool for healthcare enhancement, these companies were excluded from the study.

By the end of the clustering phase, the first group represented a list of 80 companies. Which then been contacted and requested to have an interview with the company's chief executive officer, chief technology officer, or AI department manager. Such titles have been asked as it is required to conduct the interview with a representative who is in a high level at the company and has substantial knowledge about the technical details of the business operations and the usages of AI in the business. By interviewing such representatives, we are able to collect a comprehensive opinion and insightful information regarding the use of AI in healthcare at the company. To ensure a high response rate, an introductory text about the research and researcher was created, and companies were contacted through three stages of communication. The first involved direct phone calls, the second involved sending emails, and the third involved reaching out to relevant individuals through LinkedIn messages.

3.2 Primary data collection

To collect the necessary data for this research, a semi-structured interviews typology was used, since this type is widely used for exploratory and explanatory research (Saunders et al., 2009). Interviews with six health-tech companies in Finland were conducted, these companies who responded and agreed to be interviewed. The interviews took place on Microsoft Teams and were recorded. Transcripts of the interviews were automatically produced using the auto-transcribe feature provided by Microsoft Teams. Then manually proofread and verified the generated transcripts to fix any incorrect transcriptions and ensure high quality.

After each interview, the answers of respondents have been transcribed and analysed; this helps in recognizing whether the interview questions are sufficient at an early stage, acquire the needed insights about the research questions, and be able to modify the interview questions if needed. The aim was to conduct a maximum of two interviews per week. The interviews took place between the beginning of October 2022 till the end of November 2022. Interviews happened as a one-to-one remote interview using Microsoft Teams. A remote interview format was chosen to facilitate the communication with respondents from different regions of Finland, as well as the

possibility of recording interviews to effectively review them and ensure high accuracy and understanding of the information discussed. The following section describe how these transcripts were analysed.

3.3 Data analysis

The data analysis process followed a systematic approach that consisted of eight steps: 1) familiarization with the data, 2) open coding, 3) creating a coding tree, 4) axial coding, 5) selective coding, 6) developing a conceptual framework, 7) memo writing, and 8) validation of the findings. These steps are outlined below:

1. Familiarization with the data: After transcribing the interviews, we read and re-read the transcripts to ensure accuracy and familiarize ourselves with the data.

2. Open coding: Using ATLAS.TI, we conducted an open coding process by assigning codes to relevant text segments in the interview transcripts. This allowed us to identify potential themes and patterns in the data.

3. Creating a coding tree: We developed a coding tree with initial codes based on the interview questions and revised the coding tree as new codes emerged from the data. This helped in organizing the codes and facilitated the identification of relationships among them.

4. Axial coding: We conducted axial coding by reviewing the coded data to identify relationships and patterns among the codes. To improve our comprehension of the data and pinpoint important trends, we divided the codes into categories and subcategories.

5. Selective coding: In this stage, we focused on the most significant themes and subthemes that emerged from the axial coding process. We examined these themes in greater depth and further refined our understanding of the data.

6. Developing a conceptual framework: Based on the themes and subthemes identified during the selective coding process, we developed a conceptual framework to illustrate the relationships among them.

7. Memo writing: Throughout the data analysis process, we used memo writing to record analytical notes and reflections on the data, which helped refine our understanding of the data and facilitated the development of the final themes and subthemes.

8. Validation of the findings: To ensure the reliability and validity of the findings, we conducted a member check by sharing the themes and subthemes with the interviewees to obtain their feedback on the accuracy and completeness of our interpretation.

The table below provides a summary of the interview themes, questions asked, and the reasons for asking them in a study on the adoption and usage of AI in the healthcare industry. The questions are derived from the goal of this research, which is to explore the current position of Finnish health-tech SMEs on the use of AI in healthcare and the challenges they face. This research also aims to collect opinions from industry leaders and experts on actions that can be taken to elevate the AI-Maturity level in the sector. The interview questions were semi-structured, and the themes covered a range of topics, including the company's current position on AI, the level of the Gartner AI Maturity Model, the impact experienced from the use of AI, challenges faced in adopting AI in healthcare, and future concerns around the use of AI.

Interview questions also intended to address how companies resolve issues relevant to usage of AI. Furthermore, reliable recommendations from field experts, services wished to be provided by AI solution providers, and advice for start-ups in the health-tech sector on the use of AI are, also, topics that the interview covered. All in all, the interview aimed to provide informative opinions from industry leaders and experts to develop real-world practical solutions to the challenges faced by health-tech SMEs in the adoption and usage of AI in the healthcare industry.

Interview theme	Question	Why was the question asked?
Company's current position on AI	Could you tell us about yourself and your company's activities?	Answering these questions will contribute to building knowledge about the company's current position on the use of AI in the healthcare context, thus will contribute to answering the RQ1.
	Do you consider AI use in your business solutions? (& why?)	
	At what level of Gartner AI Maturity Model is your company currently? *	
	What impact has your company experienced from the use of AI? **	
Challenges associated with the adoption and use of AI in healthcare industry	What problems did you face at the initial stage of adopting AI healthcare?	To explore and search the challenges that Finnish health-tech SMEs face in the adoption and usage of AI, and that is critical to answer the RQ2 and to develop real-world practical solutions for them.
	How did your company resolve these issues?	
	What are the current challenges the company is facing in applying AI in healthcare?	
	What future concerns do you expect to exist around the use of AI in healthcare?	
Reliable recommendations from the field experts	In your opinion, what are the actions that can resolve these challenges?	To collect informative opinions from industry leaders about action plans that can lead to elevate the AI-Maturity level in the sector.
	What services do you wish to be provided by AI-solution providers to facilitate the emergence of AI among health-tech companies?	

	What is your advice to start-ups in the health-tech sector on the use of AI?	

Table 1: A summary of the research questions asked in the interviews.

** Gartner AI Maturity model is briefly explained to interviewee before being asked the question.*
***Question is asked if it's valid and logical to be asked, thus interviews are semi-structured.*

4 Results

In this section, the results of interview analysis reports will be presented comprehensively, in a scientific manner that allows understanding and analysis of the results. As well, the most important phrases that were mentioned in the interviews about the research topic. In addition, the common observations, and trends related to the use, benefits, and challenges of embedding AI in the healthcare and wellbeing sector.

The key findings of the results are based on the analysis of the data collected through the interviews with the respondents. Appendix 1 includes some of the respondents' citations to provide further insight into the themes that emerged. However, not all key findings are represented in the appendix, as some were not explicitly stated by the respondents but were inferred from the overall interview. Therefore, it is important to read the entire interview transcript to fully understand the key findings.

This section is divided into subsections according to the key findings categories. In each subsection, it will cover the main findings by dividing the answers into groups. Also, a synthesis for the findings for each question is provided.

Category	**Key findings**
AI in products and services	● Tool for analysis ● Possible future solution ● Core product
Definition of AI	● Learning algorithm ● Quality-of-life enhancer ● Human-level anomaly detector
Additional application areas	● Marketing ● Unintentionally in existing software
Impact of AI	● Indispensable ● No impact
Data providers	● In-house data ● External providers

Computing environment	● AI entirely outsourced ● Private cloud ● Public cloud
Benefits of AI	● Speed and accuracy ● Indispensability
Needs from 3rd parties	● Resources ● Budget AI solutions
Future concerns	● Solution for staff shortage ● Positive change in healthcare ● Use in other business aspects ● Changes in regulations ● Better AI models ● Higher computational requirements
Advices for other companies	● Gather data ● Define the problem ● Hire competent people ● Start experimenting

Table 2: The main findings of the interviews.

The main findings are summarized in Table 2. What follows further in this section is a more elaborate view on each finding category. Findings on maturity level are excluded from this table because they are mainly numerical results on the level of the AI maturity of each company.

4.1 AI in products and services

Companies have considered using AI or are already embracing it in very different ways. Based on the interviews, it's possible to identify three different ways companies are using or considering AI in the health care sector. AI can be used as *a tool for analysis*, seen as a *possible future solution* or provided as their *core product*.

Companies 2, 3 and 5 reported that they use AI to conduct analysis on health data. Company 5 used AI to automatically detect anomalies in ECG analysis results whereas the other two companies used AI in a less autonomous way to analyse data for medical professionals to make better judgments. Company 2 believed firmly that they could automatize even the step where a medical

professional needs to take a look at the results and have an AI diagnose and interpret the data as well.

Companies 1 and 6 are looking into using AI in their work. Company 6 has identified that their problem of working with brain data related to epilepsy is often predictable. They envision embracing AI in the future to automatically identify when an epileptic seizure is about to happen. Company 1 has taken some steps towards processing fundus images automatically by shortlisting potential companies whose technology is mature enough to detect anomalies in such data. However, Company 1 points out the issue arising from a limited amount of data for training AI models, which might make their AI aspirations unfeasible.

Company 4 stands out from the crowd by being the only company that provides AI services as their main product. They are primarily a machine learning company and their task is to cater for health AI related needs of their clients. They provide AI solutions for diagnostic needs.

4.2 How AI is defined

AI is quite a flexible notion as it can consist of many different aspects of computing starting from simple programming to machine learning. This section will describe how the interviewed companies understand the word AI. The companies defined AI as a *learning algorithm*, *quality of life enhancer* and *human-level anomaly detector*.

Most of the companies (1, 2, 3 and 4) had a modern definition for AI, that is that it is some sort of an algorithm that ends up learning predictions based on data. Company 2 highlighted the importance of speed and that AI can be used to partially replace a costly medical specialist, however, they pointed out that medical doctors do not easily accept their AI colleague but refer to issues like privacy concerns. Company 3 also pointed out the problem of privacy by mentioning EU regulations on the use of medical data. Company 1 defined AI narrowly from the point of view of a learning classifier. They saw the lack of clean training data as an issue and a hindrance in developing AI. Company 4 wanted to point out that AI is such a large field that from their point of view, they are dealing with machine learning rather than AI.

Company 6 had not yet embraced AI, which is something reflected in the way they understood AI. For them it is a question of a quality-of-life improvement over not using an AI at all. Company 5 had the highest hopes for AI by defining it as a human-level anomaly detector. This answer

differs from the majority in the sense that the company sees AI as an unsupervised tool that can detect tendencies from data without being an actively learning agent.

4.3 Perceived level of AI maturity

This section will describe how companies perceived their own level of AI maturity following the levels established by Gartner. The interviewed companies self-identified as being in categories 1, 2 and 3. These are well in line with the discussion in the earlier sections which means that their self-reporting is rather honest in terms of how they described they actually used AI tools.

Companies 1 and 6 reported level 1 as their own level. Company 6 highlighted the issue of costs related to transitioning from an AI-aware level into a level where AI is actively used. There are costs not only related to development but also related to conforming with all regulations that are in place. Company 1 reported that their own level is currently 1, but they estimated the level of their short-listed future collaborators to be 3.

Companies 2, 3 and 5 reported their level to be 2, that is the level in which AI is applied mostly for data science needs. Company 2 also identified that they are envisioning a medical head instrument that is currently on the level 1 of AI maturity.

Company 4, which is the one relying solely on AI in their business model, was the only one reporting their level to be as high as 3. This is the level of AI in production where new value is being created through AI. The company does not have any aspirations to climb higher on the AI maturity levels because they are a small company and cannot reach the stars.

4.4 AI application areas

This section will describe how the interviewed companies for this study use AI outside of the main application area that has been described in the earlier sections. Mostly none of the companies really uses AI for any other business applications. Companies 1, 3, 4 and 6 failed to give any example on how they would utilize AI in other areas.

Company 2 identified that they do use AI in *marketing*. They host an AI-powered chatbot on their website. Apart from this, the company did not identify other uses for AI in their business.

Company 5 pointed out an *unintentional* use of AI. They only use AI in other areas because it is already baked in the software they use on a daily basis such as Microsoft and Atlassian tools.

4.5 Perceived impact of AI

AI is hardly used just because it is hip and cool but it is used because it has an impact on how business is conducted. This section will describe what the interviewed companies had to say about the impact AI has in their work. The interviewed companies thought rather unanimously that AI is *indispensable* for their operations. Only company 6 reported that AI had *no impact* thus far, but this was due to the fact that the company had not started to use AI yet. Curiously, even company 1 that does not yet use AI reported that AI is a must-have which explains why they are rather far in finding a suitable AI collaborator.

Companies 1, 2, 3, 4 and 5 said that AI is a must-have. Company further identified that conducting the level of analysis they have to do would be impossible without AI methods. Company 4, which is a pure AI company, summarized that they would not have any market value without AI. Furthermore, Company 4 indicated that embracing AI gave them an advantage in acquiring funding.

4.6 Data source

It is no secret that AI relies heavily on data. Just as the definitions for AI that were suggested by the interviewed companies, modern AI is mainly about learning from data. This section will describe the findings on what data sources the companies rely on. Data is either collected *in house* or got from *external providers*.

Companies 2, 4, 5 and 6 report the use of in-house data. In the case of company 6, it is stated as a possible hypothetical data source. For other companies, they report that their data comes from different measuring devices that monitor patients such as ECG and EEG. The aforementioned companies have not considered the need of additional complementary data from other companies or open repositories.

Companies 1 and 3 use external providers. Company 1 stated that they collaborate with manufacturers of different fundus cameras to gain more data. Company 3 has access to big data;

however, they are still looking for ways to benefit from it. This is understandable given that big data may conceal answers to many questions one does not even think of initially.

4.7 Computing environment

Given that AI relies heavily on data, another issue needs to be taken care of, namely that of a computing environment. AI models need to be trained on data, which might require high usage of computational resources. This section will describe the computing environments the companies used. The companies had either *outsourced the AI tools* entirely, used a *private server* or a *public cloud*.

Companies 1, 2 and 6 stated that either their AI tools are provided by third parties or that they will be provided by third parties. Company 2 further mentioned that their team is too small to handle their own computing environment for AI needs.

Companies 4 and 5 use public cloud providers Amazon AWS and Microsoft Azure respectively. Company 3 uses public clouds for training AI models and private servers to handle personal data. Company 6 envisions that they will start with a private server and if needed, move to a public cloud.

4.8 Challenges in AI

New technology might seemingly come with all the bells and whistles, but embracing it is not a walk in a park. This section will describe the challenges the informants talked about their companies when implementing AI and when using it. All in all, it can be identified into three main categories of challenges: *regulations*, *market acceptance* and *talent acquisition*.

If all the companies were interviewed simultaneously, it could envision that they might have said in unison that the EU has regulations too strict for health-related AI. Companies 2, 3, 4 and 6 all stated that the USA has more lenient laws on many aspects. Companies 2 and 4 had issues with *personal data regulations* in the EU. In addition, Company 4 mentioned facing legal challenges when trying to get *approval for their technology*. Company 6 faced issues with strict *medical certification requirements* that, again, are more relaxed in the USA and China. Finally, Company 3 mentions that the US medical authority FDA allows the use of AI models that are continuously

learning from data whereas the EU allows models that are trained once and tested on at least 200,000 samples. Thus, their challenge was related to the *inflexibility of the regulations*.

Companies 1 and 2 had issues with market acceptance. Both companies reported that it was difficult to get approval from medical professionals on the customer side to start using the AI in production. New technology oftentimes is met with a degree of resistance and skepticism, which might explain these findings.

Companies 5 and 6 reported a more concrete issue of being able to find competent members of staff. Both companies struggle to find people with a suitable medical background and a needed set of R&D skills in the field of AI. Perhaps this is explained by the fact that machine learning and medicine are taught as very different subjects in many universities with little to no overlap.

4.9 Perceived benefits of AI

In terms of benefits, the interviewed companies saw two main things: *speed and accuracy* and *indispensability*. This section will briefly describe what the companies had to say about these, although there are probably many more benefits that the informants didn't consider during the interview.

Companies 2, 3, 5 and 6 stated that the main benefit of AI is that it can perform laborious analysis work faster than a human being and do that with a high accuracy. This means that the problems the companies deal with are also defined well enough that the AI models have learned not to err frequently.

Companies 1 and 4 continued to see AI as a necessity. In the case of company 4, AI truly is their life-line given that their entire operations revolve around providing AI services. Company 1 also stated that there is a lot of room in the market and a lot of unsatisfied innovation potential especially in the EU for health-related AI tools, unlike in Asia, where the market is already oversaturated.

4.10 Wishes for 3rd parties

This section describes what needs the companies reported that they would have for 3rd party services to support their AI ventures. Interestingly, Companies 4, 5 and 6 reported absolutely nothing. For the other companies, the needs can be classified into *access to resources* and *budget solutions*.

Companies 1 and 2 stated that they would be interested in having access to more data from external providers. Given that AI runs on data, it is no surprise that such a need might emerge. As described in earlier sections, many companies relied heavily on their in-house data, but even so, in the world of AI more is more.

Companies 2 and 3 also expressed a need for low-cost access to AI. Especially Company 2 stated that the typical price tag of 300,000-400,000€ for an AI project if developed by an external company is way too much for a small business. Company 2 suggested either lower prices or access to funding as a solution. Company 3 advocated for cheaper access to high-performance computing so that AI models can be trained in a more cost-efficient manner.

4.11 Future concerns

The field of AI is currently in an ever-changing state with continuous innovations taking place in all fields of AI. This section describes how the informants see what the future holds for their companies when inspected through the lenses of AI. The interviewed companies had many different ideas for the future: *solutions for staff shortage, positive change in healthcare*, *use in other business aspects*, *changes in regulations*, *better AI models* and finally *higher computational requirements*.

Company 2 sees AI as one possible solution for staff shortage that results from a variety of factors such as aging population. They also believe that AI will bring a positive change to how healthcare services are provided. For example, a patient would not need to wait a long time to see a neurologist if an AI model could diagnose the symptoms automatically. Company 6 believes that AI will also change other, non-health related, aspects in their business.

Companies 4 and 5 foresee changes in regulations. Company 5 believes that AI-related privacy will be a bigger issue and a topic of societal discussion in the future. In contrast, Company 4 sees

a clear regulatory need for introducing standards to healthcare data and AI models. The current situation is a Wild West with no cohesive practices.

Companies 1 and 3 believe that the future will bring even better AI models. Company 1 presents a very practical issue that is still challenging for modern AI techniques, that is, detecting more than one symptom at a time accurately. Company 3 foresees an AI tool that can combine better information coming from different sources such as wellness data and healthcare data. These will probably lead to the future vision presented by Company 4. According to them, the demand for computational resources will skyrocket in the future as newer and newer models will require faster and faster computers to be trained.

4.12 Advices for other companies

When the companies were asked about a piece of advice for another company that has not considered AI at all, they had answers fitting the following categories: *gather data*, *define the problem*, *hire competent people* and *start experimenting*. Combined as one list of steps, these can surely provide a newcomer with a good set of instructions and a path to follow towards integrating AI in their business activities.

Companies 2 and 3 stated that the first thing to do is to gather data. As Company 2 puts it, it is better to start doing this sooner than later even if you do not have AI plans in the near future. Data is the building block of AI and if you already have it, it is easy to jump into the AI train when the time is ripe. Company 3 also states that it is important to analyse the collected data as well.

Companies 1 and 2 talked about the importance of defining the problem. The sooner you have clarity in terms of the problem you want to solve, the sooner you will know what type of data you need, according to Company 2. Company 1 calls for attention to taking extra care in specifying the goals correctly from the start. What can help with this is to hire competent people, as Company 6 suggested.

Companies 4 and 5 state that one should start experimenting with data. One can learn a great deal through playing around with the data as Company 5 suggested. Company 4 also reminded that there are several AI tools and methods that are openly available and easily bootstrappable for business use.

5 The threefold model of AI in business

To complete the development task of this research, a collaborative brainstorming development method was utilized. This method involves generating a large number of ideas and then selecting the most promising ones to pursue further (Wilson, 2013). A brainstorming session with two members from the commissioner was organized to generate solutions on what services can pave the way for health-tech SMEs to adopt and develop the use of AI, and how health-tech companies can cooperate together to elevate the level of AI in the sector. The ideas were then grouped and analysed to identify the most relevant and feasible ones. This collaborative method allowed to identify potential gaps in AI utilization in the health-tech sector and to come up with a state-of-the-art framework.

Based on the findings during the interviews, a threefold model on the use of AI in business have been elaborated. The following three categories have been identified for AI in business: *AI curious*, *AI embracing* and *AI catering* companies. This section will shed more light to each of these categories and how they differ from each other. The categorization is based on how AI is operationalized in different companies.

The model is useful when trying to understand and better analyse the use of AI from a grassroot level. This can help companies better ubicate themselves in terms of AI and business. One company does not need to fit in only one of the categories either, but a company can, for example, be AI catering in providing a specific solution for health care and AI curious when planning on integrating AI in marketing practices.

It is important to note that the highest levels of AI maturity are not part of this framework because the interviewed companies would not place themselves that high in the hierarchy. This tells us also something about the paradigm shift in the field of AI where the hard-core AI research and development is in the hands of larger companies such as Google, Meta or OpenAI and the field specific use of AI is often in hands of companies that do not have such massive resources for core AI research. Revolutionary AI methods such as word embeddings (Mikolov et al., 2013) and the Transformer model (Vaswani et al., 2017) have been developed by Google, models such as ChatGPT and DALL-E (Ramesh et al., 2022) by OpenAI and audio embeddings (Baevski et al., 2020) by Meta. In short, there is no room for a small player to compete in the space of new AI revolutions.

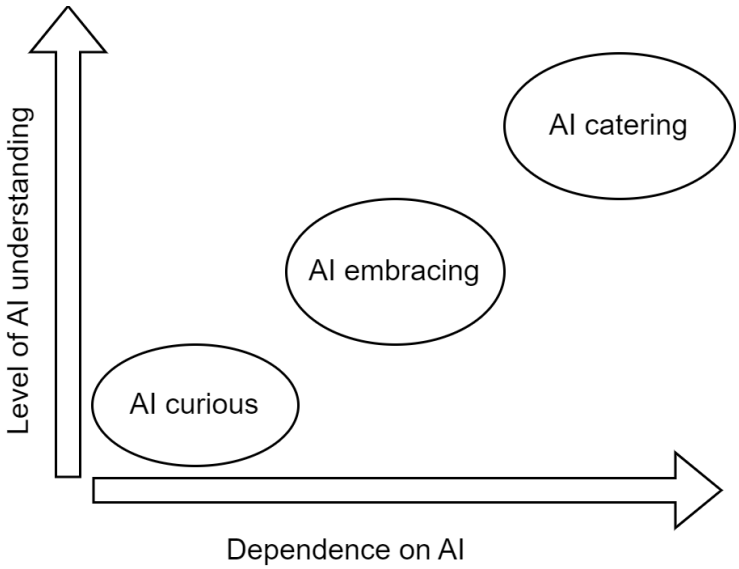

Figure 2: Threefold model of AI in business

Figure 2 outlines the three categories of AI use in business over two axes. As the understanding of AI grows, so grows the dependence on AI tools. AI curious companies are the least dependent on AI. AI embracing companies have integrated AI in their business operations and have thus become more dependent on AI tools. Finally, AI catering companies are fully dependent on AI because their business model relies solely on providing AI solutions.

5.1 AI curious

An AI curious company is still in the process of planning. Such a company can be currently identifying possible problems where AI can be used or can already be in talks with AI providing companies about solving a particular problem. AI curious companies may engage in practices of collecting data and analysing it to uncover its potential in the future when the company is ready to start using AI in their day-to-day operations.

AI curiosity can thus be a time of great exploration of both AI and its added value to the target market. AI curious companies could benefit from cost-efficient consultants, external R&D funding and existing tools and datasets. The first pitstop for an AI curious company might thus be an open data platform such as Zenodo or Kaggle or an open AI model platform such as Huggingface or Model Zoo.

At this stage, it is important that the company has a clear idea what the actual AI problem is before moving to the next stage in embracing AI. Moving on with an ill-defined problem might have costly consequences or a poor market adaptation. This calls for a degree of understanding of the current limitations and possibilities of what can and cannot be done with AI. This understanding can be acquired internally or externally.

5.2 AI embracing

AI embracing companies have already started to use AI in their business operations. However, they either do not develop AI by themselves but buy it as a service from an external provider or if they develop AI in-house, it is not their main product but rather an auxiliary tool for their actual product that could be provided without AI as well.

An AI embracing company has identified one or a few targeted problems that they can speed up by using AI. They, however, are not fully relying on AI because AI is used as a functional part of their business pipeline that also consists of manual tasks such as the final analysis or diagnosis of the numbers crunched by an AI.

A strong collaboration between an AI embracing company and their AI provider is advised. Modern AI is entirely data-driven and thus better results can be obtained if the AI embracing company is capable and willing to share their own data with their AI provider. An AI embracing company might run AI models on their own servers or on an external cloud over an API access.

5.3 AI catering

Companies that are AI catering provide AI services to other companies that are currently only embracing AI or in the AI curious stage. AI products and services are the core things AI catering companies sell to their clients. AI catering companies need not to develop their own cutting-edge AI solutions, but they can rather use existing AI methods, such as Transformers (Wolf et al., 2019), Datasets (Lhoest et al., 2021), Corpona (K. Alnajjar & Hämäläinen, 2021), Gensim (Rehurek & Sojka, 2011) and SciKit (Pedregosa et al., 2011), that they train on in-domain data to solve the business problems their customers have.

AI catering companies can provide and train AI models on their own servers or outsource the heavy computation to a cloud provider such as AWS or Azure. While AI is typically provided as a service, AI catering companies may provide their solutions so that their clients can run the AI models on their own machines.

Because the real state-of-the-art AI development has gone beyond reach for smaller companies, AI catering companies can only truly compete against each other with data. The more and better-quality data an AI catering company has, the better their AI models will be and the more advantage they will have in the market. Access to computational resources plays an important role here as well. Large amounts of data require more computational power to be harnessed in use.

5.4 Inter-categorical business opportunities

Companies in all of the three categories do not exist in a vacuum but they depend on each other on solving AI problems in the healthcare sector. This section will outline some of the ways companies in different categories can rely on each other in building tomorrow's AI solutions.

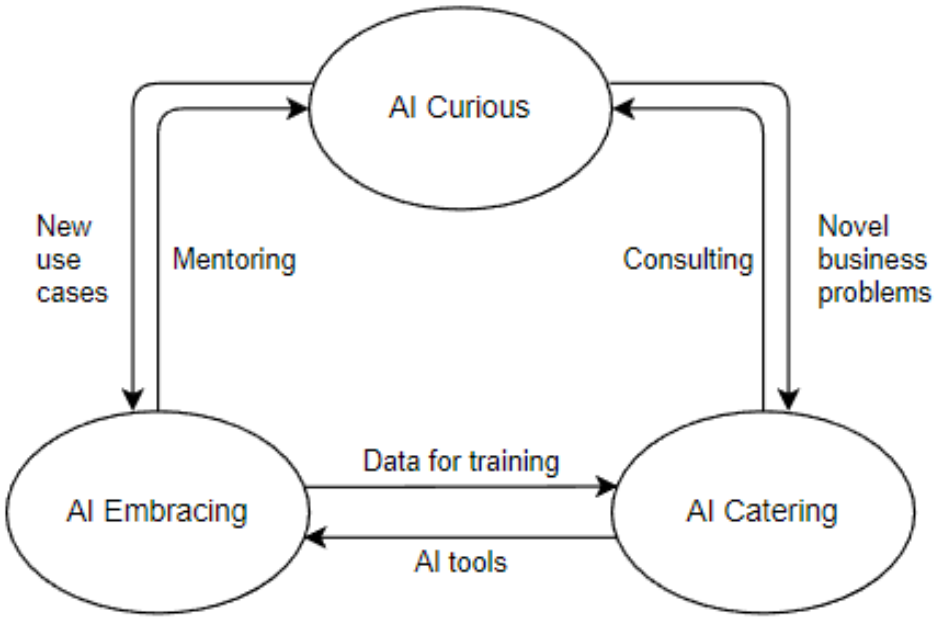

Figure 3: Interdependence of companies in different categories of business AI

An AI curious company might benefit from a company that is already embracing AI in the form of mentorship. An AI embracing company has already walked down the AI road and they can share their experience with an AI curious company. In return, an AI embracing company might get some

ideas for new use cases for the tools they are already using. This could pave the road towards a long-lasting collaboration and partnership in a new joint venture.

An AI catering company can provide direct consulting service for an AI curious company to help them better understand the possibilities of how they might use AI in their business. In return, an AI curious company might introduce a set of new business problems that an AI catering company can solve using their AI tools. This way the AI catering company can start providing new services that solve the business problems.

An AI embracing company will receive AI tools from an AI catering company on a continuous basis. These tools are directly applied in business operations. In exchange, an AI catering company can get training data from the AI embracing company. This makes it possible for the AI catering company to become better and gain market leadership.

6 Discussion

This section will further discuss the main findings and provide summaries of some of the overarching themes in the responses of the informants. It will touch upon the topics of challenges, applications and impact. The purpose of this section is to further develop contribution on the key topics of the interviews.

6.1 AI Maturity and challenges

It is interesting to see that the majority of the companies are still in the early stages of AI adoption. This highlights the potential for further growth and development in the use of AI in the health-tech sector in Finland. The early adopters of AI are likely to gain a competitive advantage and be better equipped to handle the challenges of the fast-paced healthcare industry. The companies that are experimenting with AI are likely to be testing and evaluating the potential benefits of AI before making any significant investments.

Starting with a careful analysis of the current AI maturity levels, this study found that most companies are either at the early stage of adoption or at the experimenting AI stage, and none of them have reached a high maturity level yet. However, they recognize its potential to improve healthcare outcomes, there are three challenges categories preventing them from moving further forward:

- Legal challenges
- Technical challenges
- Financial challenges

All of those interviewed stated that medical legislation and approvals are the most difficult stage of adopting the use of AI in their solutions. The current legal framework governing the use of AI for healthcare has not caught up to the speed of technology development. Innovation in health-tech companies is constantly changing and advancing, but one hurdle that has consistently impeded the adoption of AI in this field is regulatory compliance.

In Finland, and in general Europe, the regulatory framework for medical licensing and approvals is quite complex and constantly evolving, and this makes it difficult for health-tech companies to

implement new technologies like AI. If a company wishes to conduct clinical trials on a new medical device, for example, it first has to submit its product to a national administrative authority for approval, which typically takes several months and requires around 180,000 tests to prove that the AI algorithm is safe for human use. After approval is granted, the company can conduct the trial with approval from the national ethical committee, but this process can also take several months and cost a significant amount of money.

This research on the challenges faced by health-tech companies in Finland in adopting AI utilization showed that regulatory compliance and medical legislation are the most significant obstacles for these companies. The current legal framework in Europe, including Finland, is complex and constantly evolving, making it difficult for health-tech companies to implement AI solutions in their processes. This complexity is seen in the time-consuming and costly process of submitting new medical devices for approval, which involves around 180,000 tests and can take several months. The companies interviewed also highlighted the importance of obtaining approval from the national ethical committee before conducting clinical trials, which can add additional months and expenses to the process.

These results highlight the need for improvements in the regulatory framework to better support the growth and adoption of AI in the health-tech sector in Finland. The companies interviewed expressed their desire for a more streamlined and simplified process for medical licensing and approvals, which would reduce the time and cost involved and enable them to focus on innovation and bringing new AI solutions to the market. By addressing these challenges, the health-tech sector in Finland can continue to grow and thrive, improving patient outcomes and advancing the field of healthcare through the use of AI.

Two-thirds of those interviewed mentioned the difficulty finding qualified data scientists who can work with AI solutions, lack of resources and expertise required to scale an AI project to an enterprise-wide. In addition, health-tech companies are also struggling to find the right talent for their AI initiatives (as they have to have a medical background with strong programming skills). “There are currently few AI experts in the health-tech industry,” the head of one of the companies stated. Other technical challenges are collecting reliable data, cleaning and filtering data, and integration between AI interfaces with hospital systems. For example, integrating an AI solution with a legacy system is a time-consuming process that requires careful testing and careful planning. After all, there is a difficulty in confronting and convincing doctors to use these modern technologies, as most doctors base their education and training on medical skills more than technical skills. New technologies often take years to be accepted by physicians.

Some health-tech companies are facing a number of financial and cost challenges when it comes to adopting AI. The most significant challenge is that AI requires a large up-front investment, and the return on this investment may not be realized for many years. Another major challenge is that they have limited access to data with which to train the AI algorithms. In addition, costs associated with medical legislation or privacy restrictions may also be a barrier for some companies.

6.2 AI applications in health-tech sector

Majority of interviewed companies use AI for diagnostics and analysis, and they believe that AI can help improve the accuracy and speed of the analysis process. 4 out of 6 companies stated their plans to invest in AI in the future and all of them consider AI a top priority for their company. In general, the companies believe that integrating AI into their system will make them more competitive in the market. The utilization of AI in the healthcare industry promises to speed up medical diagnosis and improve patient outcomes. In the future, we will see more companies adopting AI as a cornerstone of their analytics platform to improve patient care and enhance business operations. Most of the interviewed healthcare technology companies are using AI to increase efficiency in their clinical diagnostic analysis or data collection. Some are planning to deploy AI systems in order to improve decision making. They believe that by integrating AI into their business they will be able to reduce operating costs and increase revenues.

Our findings align well with the literature review as both suggest that AI has the potential to transform healthcare significantly, and organizations that integrate AI can anticipate major benefits like increased efficiency, better patient outcomes and lower costs. To ensure that AI is integrated responsibly and ethically in healthcare systems, health-tech SMEs must prioritize investment in AI and collaborate closely with technology partners.

6.3 AI impact

AI technology has had a significant impact on health-tech companies, as it has become indispensable for their operations. This influence is due to the great outcomes that AI brings to the table, not merely the hoopla surrounding it. This section will discuss the results obtained from analysing how the companies interviewed perceive the impact of AI on their business activities. Remember that one of the companies interviewed has yet to employ AI, while the others considered it as a

must-have technology in their operations. Even the company that did not utilize AI, however, acknowledged the importance of AI and is actively seeking suitable AI collaborators.

The majority of organizations (1, 2, 3, 4, and 5) interviewed stated that AI is an important part of their business. Company 6, which has not yet adopted AI, cited the inability to assess its impact due to the lack of AI implementation. Company 3, in particular, emphasized that without AI, it would be impossible to conduct the level of analysis required for their business activities. On the other hand, Company 4, which is purely an AI-based company, stated that they would not have any market value without AI. In fact, embracing AI has given them an advantage in acquiring funding.

The positive impact of AI on health-tech companies is not just limited to improving their business processes, but it also offers significant advantages to patients. For instance, AI can aid in earlier detection and diagnosis of diseases, as well as the provision of personalized and targeted treatments. AI can also help healthcare practitioners make more educated judgments by analysing massive volumes of data and spotting trends that human clinicians may miss.

The companies interviewed unanimously agree that AI is a must-have in their operations, and those that have already embraced AI technology have seen positive outcomes, including better business processes and funding opportunities. The value of AI in the healthcare industry cannot be emphasized, since it benefits not only health-tech companies but also patients.

6.4 Valuation of reliability

The work presented in this study is supported by a rigorous methodology, including comprehensive interviews with key stakeholders and the use of thematic analysis for data examination. While the findings offer valuable insights, their applicability to other contexts might be limited due to the study's focus on a relatively small sample of Finnish healthcare SMEs. It is crucial to understand that the viewpoints expressed by the respondents are subjective and might not accurately reflect those of all sector players.

6.5 Ethical considerations

Throughout the research process, ethical considerations were duly addressed. All participants provided their informed consent, and their privacy and confidentiality were maintained through data anonymization and safe information storage. The research also acknowledged the ethical challenges of AI adoption in healthcare, such as data privacy, algorithmic bias, and accountability, and put forth recommendations that address these concerns.

6.6 Applicability and advantages for the client

This study's results can help healthcare SMEs, policymakers, and other interested parties comprehend the present state of AI adoption in the Finnish healthcare industry, recognize opportunities and hurdles, and devise strategies to encourage AI adoption effectively. The suggested threefold model of AI in business can serve as a practical tool for guiding companies in their AI adoption journey, while the recommendations provided can support them in overcoming obstacles and maximizing the benefits of AI. By incorporating AI into their operations, healthcare SMEs can enhance their competitiveness, improve patient outcomes, and contribute to the overall progress of the healthcare industry.

6.7 Recommendations

Based on the interview with these companies and the described results along with their analysis, the following are this thesis recommendations to enhance the current state of AI utilization in health-tech companies, especially in the EU and Finland.

The first recommendation is for policymakers and governments to introduce a regulatory framework that is more lenient and flexible for health-tech companies to integrate AI into their solutions while taking into account the sensitive and private nature of medical information, added health benefits for patients, and potential gains for SMEs in the region such as giving them a bigger competitive edge in the global market. The framework needs to simplify and streamline the entire process of research and developing AI solutions in health-tech, and the process of medical licensing and approvals to allow such companies to concentrate on innovation and employ novel AI approaches to the market.

The second recommendation addresses the difficulty for health-tech SMEs to find qualified talents that are capable of integrating and using AI in health contexts (e.g., data scientists, AI experts and medical practitioners), which is investing in developing the necessary talent and expertise required for building and scaling AI projects in the industry. This can be done, for instance, by reducing the desired requirements lightly and enrolling talents into continuous training that focuses on AI from various perspectives within the domain of healthcare. Alternatively, attracting foreign experts that satisfy the needed requirements with competitive deals, benefits and salaries would open the door for such companies to acquire top talents and utilize AI.

As stated earlier, financial barriers are one of the main difficulties faced by SMEs for making use of AI, because AI requires a significant up-front investment, and the return on this investment may not be realized for years to come. Hence, we recommend developing funding mechanisms that permit health-tech SMEs to access the necessary financial resources via governmental, private, local or foreign funds.

We also suggest building a platform for matching health-tech SMEs with other entities in the country and abroad based on the AI needs of SMEs and the expertise/services that the other entities can provide. Doing so allows health-tech SMEs that desire to utilize AI to be able to achieve that regardless of their skills and knowledge in AI; therefore, facilitating the entire development and integration process while ensuring that both companies benefit from each other (whether financially by paying the other entity or in other means such as supplying them with medical data that is difficult to come by in exchange for AI solutions, for example).

Lastly, we recommend introducing a license for working with private data such as the one present in the healthcare sector and data privacy regulations concerning the processing and storage of such data. The license would ensure that the holder is knowledgeable and capable of working with private data and they would be responsible for any leakage, deletion or tampering with it. The regulations on the other hand would enforce a rigid process for anonymizing private data, storing it in a secure and encrypted format, backing it on a regular basis and permit licensed experts to access the data only when authorized to do so while keeping logs of all actions performed to guarantee the integrity of the data.

7 Conclusion

In conclusion, the healthcare industry is a vast sector that involves different fields such as pharmaceuticals, diagnostic services, medical surgeries, and wellbeing. Artificial intelligence (AI) is changing the healthcare and wellbeing industry by improving patient monitoring, diagnosis, and treatment. In order to build cutting-edge goods and services that can improve human health and save lives, health tech companies are making significant investments in the research and development of AI technology. The application of AI in healthcare has a lot of potential, and businesses are aware of the advantages it may offer in terms of individualized care and lighter workloads for medical staff. A results summary will be presented here followed by future directions and discussion from the researcher's point of view. In addition to mentioning the limitations of this research, and how future research can be done to provide more concrete AI-related practices.

The aim of this thesis, which is investigating how Finnish healthcare SMEs are implementing AI in their operations, what are their needs and what type of challenges they face was studied by conducting semi-structured interviews with representatives working in Finnish SMEs in the health-tech sector. This research also shed light on the obstacles small and medium-sized enterprises (SMEs) deal with when adopting AI, such as financial, technical and legal difficulties. The possibilities for using AI and the need for AI were uncovered and identified through the interviews, along with the current AI-Maturity level of these companies. Additionally, this research has led to the creation of a threefold model of AI in business, as well as recommendations for healthcare companies on how to utilize AI effectively in their activities.

All the research questions of this thesis have been addressed. RQ1 was tackled by providing an overview of the level of AI utilization by Finnish health-tech SMEs, based on the interviews conducted. As a result, most of the companies have been identified as AI-curious, interested in exploring the potential of AI but have not integrated it into their operations yet. Regarding RQ2, the constraints that Finnish health-tech SMEs face when adopting AI solutions, such as financial, technical, and legal challenges, as well as potential errors in diagnosing patients introduced by computational solutions. By exploring the services that Finnish SMEs need to support them in developing and adopting AI solutions in their business activities, such as AI consultation, support in data collection and processing and access to AI tools and platforms RQ3 have been answered. For the last research question, RQ4, some had been proposed in which Finnish companies having different levels of AI maturity can support and help each other to achieve efficient AI utilization,

such as sharing best practices, collaborating in research and development, and building a community of AI adopters by introducing the threefold model of AI in business.

The threefold model consists of companies that are AI-curious, AI-embracing and AI-catering. AI-curious refers to companies that are interested in exploring the potential of AI but have not integrated it into their operations, while companies that already incorporate AI in their business processes are deemed as AI-embracing. AI-catering companies are those that develop AI solutions and provide them to other businesses or individuals. The deployment of AI in healthcare poses some challenges, such as privacy concerns and the need for extensive testing and validation to avoid errors. Yet, given the immense potential benefits of AI for the healthcare sector, this research contributes to how healthcare organizations might use AI to their advantage.

AI has taken a long way for more than 60 years, yet it will not end soon, there are countless untapped opportunities benefiting from AI, especially in the healthcare industry. Internet of things, safe public clouds, and the digitalization revolution in business all are factors to support AI-enabled healthcare. This thesis is but the tip of the iceberg of research to pave the way of AI adoption. A future direction is to investigate the impact of AI on healthcare outcomes in companies that are already employing AI.

Exploring the ethical and legal implications of AI in healthcare is certainly a topic worth studying further as many SMEs have concerns regarding them. Moreover, examining the role of public-private collaborations in facilitating AI adoption within healthcare SMEs can provide valuable insights into how partnerships can be leveraged to overcome barriers and accelerate progress. The examination of the impact of regulatory changes on healthcare AI adoption and provide policy recommendations, balancing innovation with safety and ethics is worth studying in the future too. Furthermore, investigating AI's long-term effects on healthcare professionals' roles and responsibilities is crucial for understanding the industry's evolution and creating relevant education and training programs. There are multiple emerging technologies such as blockchain and 5G networks, and studying their adaptability in AI-enabled healthcare are topics to study. Additionally, future research could focus on the development of more concrete AI-related practices and solutions for healthcare organizations. Overall, continuing this research is necessary to fully understand and maximize the benefits of AI in health-tech as it has a great potential for revolutionizing the field.

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Document	Citation	Category/Key findings
Company 1	Detecting more than one symptom reliably from AI, what makes it harder is to get access for huge numbers of images to train the AI and proof if its work	Future concerns Positive change in healthcare
Company 1	AI is a must to have in the (company's product) market, and already all (the product) manufactures have an integration to AI solutions.	Impact of AI Indispensable
Company 1	We are not using AI in any of the company's operations.	Impact of AI No impact
Company 1	Defining a clear goal by clinicians to what they want to achieve from the use of AI.	Advices for other companies Define the problem
Company 2	AI is used in marketing at a small scale, like chatbot on the web page	Additional application areas Marketing
Company 2	AI is about learning algorithm that speed up measurement processes and interpret results without the need of a specialist, which spare their time and do processes fast.	Benefits of AI Speed and accuracy
Company 2	The aging population in Europe and the declining in workforce, maybe will boost the adoption of AI and it will just come automatically accepted in the market in the future.	Future concerns Solution for staff shortage
Company 2	For small companies, they need an easy access for resources that could help them do AI.	Needs from 3rd parties Resources
Company 2	Think about the services that can be integrated by AI, as this will give a competitive edge once the acceptance is there. Even before using AI, company could gather data, thinking about the setup, prepare for it, so once its time to implement AI it will be easier.	Advices for other companies Gather data Start experimenting
Company 3	The use of AI is in the analytics of data in the service we provide to our customers	AI in products and services

Company 3	At (the company) public clouds are used primarily because of security concerns and compatibility, used to analyse and access measurement information such as number of people infected with a particular disease in a particular area, without having the patient's info. And private servers used to handle patients' information, it is encrypted, and a cybersecurity system is used.	Computing environment Hybrid: public and private
Company 3	Start collecting data, appreciate the data, find out how you can use it, and specialized data analytics is required especially in the healthcare field.	Advices for other companies Gather data Hire competent people
Company 4	(AI) as a way to teach algorithms or make them teach themselves to give us better results in the future as the data base grows.	Definition of AI Learning algorithm
Company 4	Computing power is one of the main challenges that will be in the future, especially for those companies who have huge data and systems.	Future concerns Higher computational requirements
Company 4	If we didn't use AI, then we will have no added value to the market and just be like any other company in the market.	Impact of AI Indispensable
Company 5	Our company uses AI in areas other than analysing ECG records, but it uses it unintentionally by using tools such as Microsoft and Atlassian solutions which already have AI solutions for the work management.	Additional application areas AI in products and services
Company 5	Public clouds by amazon AWS are used to collect the records, and then share it with the AI solution partner company to use it on their servers for the analysis and to provide reports based on the data	Computing environment AI entirely outsourced
Company 5	An algorithm that can see the disturbances as well as a human with a good understanding of the (medical signal).	Definition of AI Human-level anomaly detector

Company 5	When we start adding other parameters such as oxygen saturation, blood pressure, motion detection, and so on to the analytics, we will need higher computation performance.	Future concerns Higher computational requirements
Company 5	Now adays AI is a must to have to analyse the records and provide a valuable solution.	Impact of AI Indispensable
Company 5	Start developing skills and understanding about the capabilities of AI and start your experimenting with it.	Advices for other companies Start experimenting
Company 6	Currently we only use AI in the software in our product, but we may consider in future to use AI in other business aspects	AI in products and services
Company 6	We started with some private clouds, but now we transitioning to public clouds.	Computing environment
Company 6	It is a quality-of-life enhancement tool for AI and that's the long-term vision.	Definition of AI Quality-of-life enhancement