

# **Considering EU regulations during NPD Process of AI solutions for healthcare**

**EU:n regulaatioiden huomioiminen uusien  
terveydenhuollon tekoälyratkaisujen tuotekehityksen  
aikana**

Kandidaatintyö

## ABSTRACT

**Author: Joonas Kostamo**

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This bachelor's thesis compiles EU regulations affecting product development of artificial intelligence solutions for healthcare. A literature review is performed on the regulations, and the relevant technologies and their development. The effects of these regulations are then considered in the context of a generic new product development process model.

AI is expected to bring many changes and new possibilities for the healthcare industry. The EU has recognized the potential of emerging AI technologies and their applications, as well as the risks associated with them. The general data protection regulation recently put in place by the EU to protect citizens' privacy rights and data safety largely affects AI as a data driven technology. Regulations on medical devices are currently undergoing change as well, and affect most products placed on the market for healthcare purposes.

Dealing with regulations during development efficiently can help direct development efforts towards ideas with higher chances of success, reduce the time and costs required to demonstrate conformity, and prevent failure to comply and its legal consequences.

## TIIVISTELMÄ

**Tekijä: Joonas Kostamo**

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Tämä tutkielma koostaa terveydenhuollon tekoälyratkaisujen tuotekehitykseen vaikuttavia EU:n regulaatioita. Regulaatioihin ja asiaankuuluviin teknologioihin, sekä niiden tuotekehitykseen, perehdytään kirjallisuuskatsauksen keinoin. Regulaatioita vaikutuksineen tarkastellaan geneerisen uusien tuotteiden tuotekehitysprosessimallin vaiheiden kautta.

Tekoälyn voidaan uskoa tuovan monia uusia mahdollisuuksia terveydenhuoltoon. EU on tunnistanut uusien tekoälyteknologioiden mukanaan tuomat mahdollisuudet, sekä niihin liittyvät uhkat. EU:n käytäntöön panema yleinen tietosuoja-asetus vaikuttaa laajasti tekoälyn kehitykseen datakeskeisenä teknologiana. Terveydenhuollon tarkoituksiin kehitettyihin laitteisiin ja niiden kehitykseen vaikuttavat myös lääkinnällisiä laitteita käsittelevät asetukset, jotka myös ovat muutoksen alla.

Regulaatioiden huomioiminen tehokkaasti uusien tuotteiden tuotekehitysprosessin aikana voi auttaa keskittämään kehitystyön ideoiden toteuttamiseen, joilla on paremmat mahdollisuudet onnistua, vähentää regulaatioiden mukaisuuden osoittamisen viemää aikaa ja kustannuksia, sekä ennaltaehkäistä epäonnistumisia noudattaen regulaatioita seurauksineen.

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# 1 INTRODUCTION

## 1.1 Background

During recent years money spent on healthcare services and products in the EU countries has been growing steadily. In the EU countries in 2017, on average 9.81% of GDP was spent on healthcare, with the countries with the oldest population spending the largest proportions of their GDP on it. (Rokicki, Perkowska and Ratajczak 2021) Increasing number of people retired from the workforce due to population ageing is the most important demographic challenge that the EU is currently experiencing (Rychtaříková 2019). Older the population, the more age-related medical conditions there will be that need to be treated. To make things worse as the population ages, the proportion of retired people compared to the workforce is bound to increase. One potential solution to the challenges of delivering quality healthcare to a larger customer base cost effectively is Artificial Intelligence (AI) powered automation of healthcare tasks.

AI is going to change almost every aspect of our lives. Despite the many obstacles AI technology has yet to overcome, it has the potential to greatly affect consumers, companies, and governments alike. In the immediate future AI can empower our lives. One important path to this empowerment is the AI amplification of human abilities. AI already has a significant role in multiple industries and applications, some of which greatly affect the healthcare industry. Medical diagnostics systems involving AI are a real-world example of such applications. The impact AI has had on the labor market so far may only be the beginning of a total transformation of the workplace. (Martínez-Plumed, Gómez and Hernández-Orallo 2021)

Unprecedented progress in AI during the last decade has demonstrated the potential benefits of the technology for many fields, including medicine. AI techniques can provide these fields with valuable insight extracted from data. (Esteva, Chou, Yeung, Naik, Madani, Mottaghi, Liu, Topol, Dean and Socher 2021) However these fast and envious advances in AI are bound to face a wide variety of regulatory challenges, especially concerning AI usage of data and privacy (Chatterjee 2019). The European Union has decided to pursue a leadership position in the AI sector, hoping it will benefit the bloc's future development (Cabral 2020). To reach this goal,

regulation and legislation concerning AI must also be up to date in the EU. In the global landscape EU has decided to follow a comparatively cautious, heavily regulated approach to AI by considering all risks and placing full responsibility of any damage caused by AI applications on the creator and controller of the AI and its application (Vasiliev, Zemlyukov, Ibragimov, Kulikov and Mankovsky 2019).

From the point of view of companies aiming to develop AI solutions for the healthcare industry, these comparatively strict regulations however can be a challenge. In the EU regulations on AI as well as on medical devices complicate product development of AI incorporating products intended for medical use. Especially smaller companies with less regulatory expertise available can struggle with taking different design choices' regulatory implications into account during product development.

## **1.2 Purpose and research questions**

The purpose of this research is to provide a concise summary of regulations affecting product development of medical devices incorporating AI in the EU. The aim is to present these regulations in conjunction with the phases of product development that are impacted by them. The end goal is to help companies take these regulations into account as necessary all the way through product development by providing them with an easy to understand and incorporate example of a product development process that takes these regulations into consideration. Following the example put together in this bachelor's thesis, companies can hopefully save costs, labour and time when developing AI solutions for the healthcare industry. By compiling these regulations with this example product development process this research aims to answer the question:

In the EU which regulations affect incorporating AI in medical devices and how?

This research question can be divided to three sub-questions:

Q1: How AI in medical devices is regulated in 2021 in the EU?

Q2: What is required to certify a medical device incorporating AI?

Q3: How should these regulations be considered during product development?

Leveraging technologies such as artificial intelligence and machine learning can open up a huge avenue for local small and medium businesses and help them benefit from the modern global market. However, every organization attempting this faces a different set of issues and challenges specific to the business segment as well as the industry, which the enterprises are involved in. (Rakheja 2018) Thus, the solutions to effectively tackle these challenges also need to be specifically tailored for these separate sets of issues.

This research aims to specifically make facing these challenges easier for companies developing AI solutions for professional use in the healthcare industry. The exclusion of products and companies attempting to find a foothold predominantly on the consumer market has been done to make the research more precisely applicable to a smaller set of companies. This should make the findings more useful and practical for the companies fitting to the scope selected for this research. By providing easy to apply information on the regulations affecting this business segment this research aims to ultimately improve public health and reduce cost of healthcare.

In the EU regulations on medical devices are currently undergoing a transition period. Three older directives are being replaced by two new ones. The older directives are (Directorate-General for Communication 2021):

- Council Directive 90/385/EEC on Active Implantable Medical Devices (AIMDD) (1990)
- Council Directive 93/42/EEC on Medical Devices (MDD) (1993)
- Directive 98/79/EC of the European Parliament and of the Council on in vitro Diagnostic Medical Devices (IVDMD).

And the new directives are (Directorate-General for Communication 2021):

- Regulation (EU) 2017/745 of the European Parliament and of the Council of 5 April 2017 on medical devices, amending Directive 2001/83/EC, Regulation (EC) No 178/2002 and Regulation (EC) No 1223/2009 and repealing Council Directives 90/385/EEC and 93/42/EEC
- Regulation (EU) 2017/746 of the European Parliament and of the Council of 5 April 2017 on in vitro diagnostic medical devices and repealing Directive 98/79/EC and Commission Decision 2010/227/EU

Even though the transition period for some regulations was extended due to the coronavirus pandemic (Directorate-General for Communication 2020a), this research will only consider the new regulations. As product development takes time, and this research aims to be applicable from the beginning of the process, the decision was made to exclude the old regulations from the scope of this research.

In addition to regulations set by the EU, national regulations might also need to be considered. To keep the extent of this research manageable, national regulations are left outside of the scope of this research.

### **1.3 Structure and goals**

This bachelor's thesis consists of six segments, each serving their own purpose towards answering the research questions. The segment following this introduction defines the AI terminology used in this research and presents different aspects of AI to be considered in the later segments. Then the role of AI is outlined in the context of professional healthcare. The fourth segment introduces the regulations relevant to product development in this field. Then these regulations are considered from the point of view of product development and its different phases. Finally, the synopsis and conclusions are presented.

The goal for the first three segments is to provide enough background information and context to ensure the latter half of the research is unambiguous. The segments four, five and six answer the research questions by building on to the information provided in the first half of the research.

### **1.4 Research methods**

This research has been conducted following literature research methodology. Most important types of sources used are legislative regulatory acts of the European Union published by the Official Journal of the European union, online guidance documents for these regulations, and scientific journal articles.

Some of the most important search terms used to find literature sources for this research are:

- Artificial intelligence regulation
- Data regulation
- Healthcare regulation
- European Union regulation
- Artificial intelligence product development
- Healthcare product development
- New product development process

As the EU legal and regulatory framework is one of the focus areas of this research, to reduce the risk of providing misleading or false interpretations of the law some sources concerning the regulations have quite extensively been quoted directly. Some of these quotations have been embedded into regular text paragraphs, while others can be found in the attachments.

Often however direct quotations cannot be used while also maintaining good readability and cohesion. To maintain the original meaning of the regulatory sources as well as possible in these instances, the sources in question have been referenced in a way that is more loyal to the original source than is typical in literature research.

## 2 ARTIFICIAL INTELLIGENCE

### 2.1 AI terminology

Artificial Intelligence is constantly evolving, which makes it challenging to define the term in a clear and easy to grasp manner. AI is a high-level term that covers a wide area of computer science applications. AI as a technology has gathered extreme levels of interest from investors and consumers alike, referring to non-AI software solutions as AI has become a widely utilized deceptive tactic to boost interest in products and companies (Bini 2018). While there is no single universally accepted definition of AI, it is necessary to select a definition to be used throughout this bachelor's thesis to avoid contributing to this "AI washing" mentioned by Bini (2018) as well as to make sure the results of this research can be interpreted as intended.

Artificial Intelligence is defined by Stone, Brooks, Brynjolfsson, Calo, Etzioni, Hager, Hirschberg, Kalyanakrishnan, Kamar, Kraus, Leyton-Brown, Parkes, Press, Saxenian, Shah, Tambe and Teller (2016) as a "science and a set of computational technologies that are inspired by—but typically operate quite differently from—the ways people use their nervous systems and bodies to sense, learn, reason, and take action". Haenlein and Kaplan (2019) in turn introduce "a system's ability to interpret external data correctly, to learn from such data, and to use those learnings to achieve specific goals and tasks through flexible adaptation" as a common definition for AI. The definition used in this research has been created by combining the two forementioned definitions to create a single more appropriate definition for the purposes of this particular research. This bachelor's thesis uses the following definition produced by combining the two forementioned definitions: "Artificial Intelligence is a science and a set of computational technologies that" (Stone et al. 2016) enables computers "to interpret external data correctly, to learn from such data, and to achieve specific goals through flexible adaptation" (Haenlein and Kaplan 2019).

AI can be labeled as narrow or general based on the tasks it can perform. Narrow AI performs one narrow task with a clearly defined scope, while artificial general intelligence (AGI) can perform any intellectual task that a human can do (Bughin, Hazan, Ramaswamy, Chui, Allas,

Dahlstrom, Henke and Trench 2017). This research only considers narrow AI, as successful creation of AGI is not expected to occur any time soon (Borana, 2016).

## 2.2 Machine learning

Machine learning (ML) is the most popular branch of narrow AI (Selvaraj 2019). In machine learning a computer is fed a set of learning data to study. The computer learns to perform a task based on the example problems and solutions it has been given. The computer then can perform the same tasks and create solutions with data it has not encountered before, based on what it learned from the training data. (Hinchey 2018) ML is by and large related to computational statistics, as both focus on making predictions with computers (Xin, Kong, Liu, Chen, Li, Zhu, Gao, Hou, and Wang 2018).

Deep learning, or DL, is a subset of ML which aims to emulate the biological neural structures found for example in the human brain by creating multiple layers of interconnections (Selvaraj 2019). These layers of information processing can be exploited for pattern classification and unsupervised feature learning (Mishra, Gupta 2017). The information processing at these layers is performed by functions of intermediate variables called labels. Labels can also be referred to as hidden variables, intermediate features, nodes or neurons. The outputs of these labels are then used as inputs for the following layer. This chain of labels passing on intermediate variables with information processing functions altering the variables at each stage makes up a deep neural network (DNN). (Wainberg, Merico, DeLong and Frey 2018)

ML algorithms can be inscrutable, as the way they end up processing data has been developed through automation. Furthermore, what makes ML-based algorithms' outputs extremely hard to explain is the fact that they are produced using millions of hardly interpretable parameters that are altered and optimized during the training stage (Stepin, Alonso, Catala, and Pereira-Farina 2021). DNN approaches have emerged to be very popular, despite the fact that this inscrutability can be especially significant with them. This can hamper users' trust towards these algorithms, especially when they are responsible for making decisions with significant consequences, potentially leading to the rejection of the system incorporating ML. As the inner

workings of algorithms like this are hard or nearly impossible to understand, discovering biases in the decision making of the system is also made more difficult. (Rai 2020)

### **3 HEALTHCARE INDUSTRY AND AI**

The role of AI in healthcare is becoming increasingly important. AI is currently being developed and implemented for many different targeted healthcare applications, such as medical diagnostics, patient monitoring, and learning healthcare systems. (Lysaght, Lim, Xafis and Ngiam 2019) The healthcare industry can also benefit from many AI applications not exclusive to the industry itself, such as logistics robots.

As AI in healthcare is an emerging field, the number of articles published on the subject is on the rise. Articles on AI in healthcare have discussed mostly applications including medical, dental and hospital equipment, surgical and medical instrument manufacturing, equipment repair and maintenance, and surgical appliances and supplies. Less discussed categories for AI products include patient care, predictive modes/decision support systems, system management and automation/robotics. (Shah and Chircu 2018)

Telemedicine and mobile healthcare could solve some of the difficulties of accessing healthcare for aging populations in rural areas. Patients could be tracked and monitored through wearable devices equipped with communication capability. Remote service with telemedicine and remote diagnosis can also be beneficial especially for rural areas. Remote healthcare service and the medical devices involved could utilize AI technologies for many purposes, such as processing and analyzing the data collected by the devices, and decision support systems for doctors performing remote appointments. (Vongsingthong and Smanchat 2014)

Modern day clinical specialists have access to an extensive amount of information to be evaluated. Diagnostic processes can be streamlined by employing AI methods for computer aided diagnosis, which can decrease risk of misdiagnosis. Adaptive machine learning algorithms can be used to process multiple different types of medical data. AI methods have already proven useful for analyzing a multitude of different types of samples and measurements collected, such as blood and urine samples, and radiographs. Use of artificial neural networks as a tool for diagnosis provides several advantages including the ability to automatically process massive amounts of data, reduced risk of overlooking important information, and faster diagnosis. (Amato, López, Peña-Méndez, Vañhara, Hampl and Havel 2013)

Big Data applications for healthcare have garnered a lot of interest during recent years. Internet of Things (IoT) approaches can be used to collect data for Big Data type analysis and improvement of processes by healthcare professionals. IoT is based on multiple devices collecting data and exchanging it with other devices in the network. Objects that are connected to the IoT by identifiers or sensors can be managed, analyzed, and inventoried by computers. Implementing IoT systems can help healthcare facilities improve supply chains, change processes, and update procedures. (Perry 2016) AI solutions are needed to fully benefit from this massive amount of data collected from the large number of devices in the IoT system. As the principle behind IoT is based on many devices communicating with each other, deploying ML solutions to avoid congestion of the network is also necessary (Merenda, Porcaro and Iero 2020).

While there are many promising applications for AI technologies in the healthcare industry, regulatory compliance issues and privacy concerns of consumers are slowing down their adoption by healthcare organizations (Tsang, Kracov, Mulryne, Strom, Perkins, Dickinson, Wallace, and Jones 2017). Companies able to overcome these obstacles can be expected to gain significant competitive advantages by leveraging these technologies.

## **4 AI REGULATIONS IN HEALTHCARE IN THE EU**

Regulations in place for products utilizing AI intended for use by medical professionals are complex, as both regulations affecting AI and healthcare products must be taken into consideration. The purpose of this section is to provide a general look into the regulations concerning AI in the healthcare industry in the EU, and to compile some of the most relevant information from the perspective of product development. The author of this bachelor's thesis has no legal expertise. Nothing stated here is legal advice.

This section can also be used as a guide to identify which medical device regulation likely covers a software product and which device classification it most likely falls under based on its properties, inherent risk and intended purpose.

### **4.1 EU medical device regulations**

New regulations replacing the old ones concerning medical devices in the EU are Regulation (EU) 2017/745 of the European Parliament and of the Council of 5 April 2017 on medical devices, amending Directive 2001/83/EC, Regulation (EC) No 178/2002 and Regulation (EC) No 1223/2009 and repealing Council Directives 90/385/EEC and 93/42/EEC, and Regulation (EU) 2017/746 of the European Parliament and of the Council of 5 April 2017 on in vitro diagnostic medical devices and repealing Directive 98/79/EC and Commission Decision 2010/227/EU (Directorate-General for Communication 2021a) For the purposes of this research Regulation (EU) 2017/745 will from now on be referred to as MDR and Regulation (EU) 2017/746 as IVDR.

MDR lays down rules for placing on the market, making available on the market, or putting into service of medical devices and their accessories in the EU. The MDR also applies to clinical investigations concerning medical devices and their accessories performed in the EU. For the definition of 'medical device' under the MDR, see attachment 1. (Official Journal of the European Union 2017a)

MDR does not apply to in vitro medical devices covered by IVDR, and IVDR does not apply to medical devices covered by the MDR. This means that any given device can only be covered by one of the regulations. If a device consists of multiple integral parts that fall under each regulation, each part is governed by the regulation concerning the part itself. (Official Journal of the European Union 2017a, 2017b)

IVDR lays down rules for placing on the market, making available on the market, or putting into service of in vitro diagnostic medical devices and their accessories in the EU. The IVDR also applies to performance studies on in vitro diagnostic medical devices and their accessories performed in the EU. For the definition of ‘in vitro diagnostic medical device’ under the IVDR, see attachment 2. (Official Journal of the European Union 2017b)

Devices intended by its manufacturer specifically for the primary containment and preservation of specimens derived from the human body for the purpose of in vitro diagnostic examination are also deemed to be in vitro diagnostic medical devices. (Official Journal of the European Union 2017b)

As both MDR and IVDR are applicable to software, these regulations must be taken into account when designing AI for healthcare. The following instructions created based on MDR and IVDR can be used to assess which regulation applies to a specific product or component. The first step is to see if MDR definition of medical device applies. If it does, it is governed by the MDR, if not it might be covered by the IVDR.

If the IVDR definition of in vitro diagnostic medical device applies to the product or the component, it is covered by the IVDR unless any of these factors exclude the product from the scope of IVDR. IVDR does not apply to:

- “(a) products for general laboratory use or research-use only products, unless such products, in view of their characteristics, are specifically intended by their manufacturer to be used for in vitro diagnostic examination
- (b) invasive sampling products or products which are directly applied to the human body for the purpose of obtaining a specimen
- (c) internationally certified reference materials

(d) materials used for external quality assessment schemes”

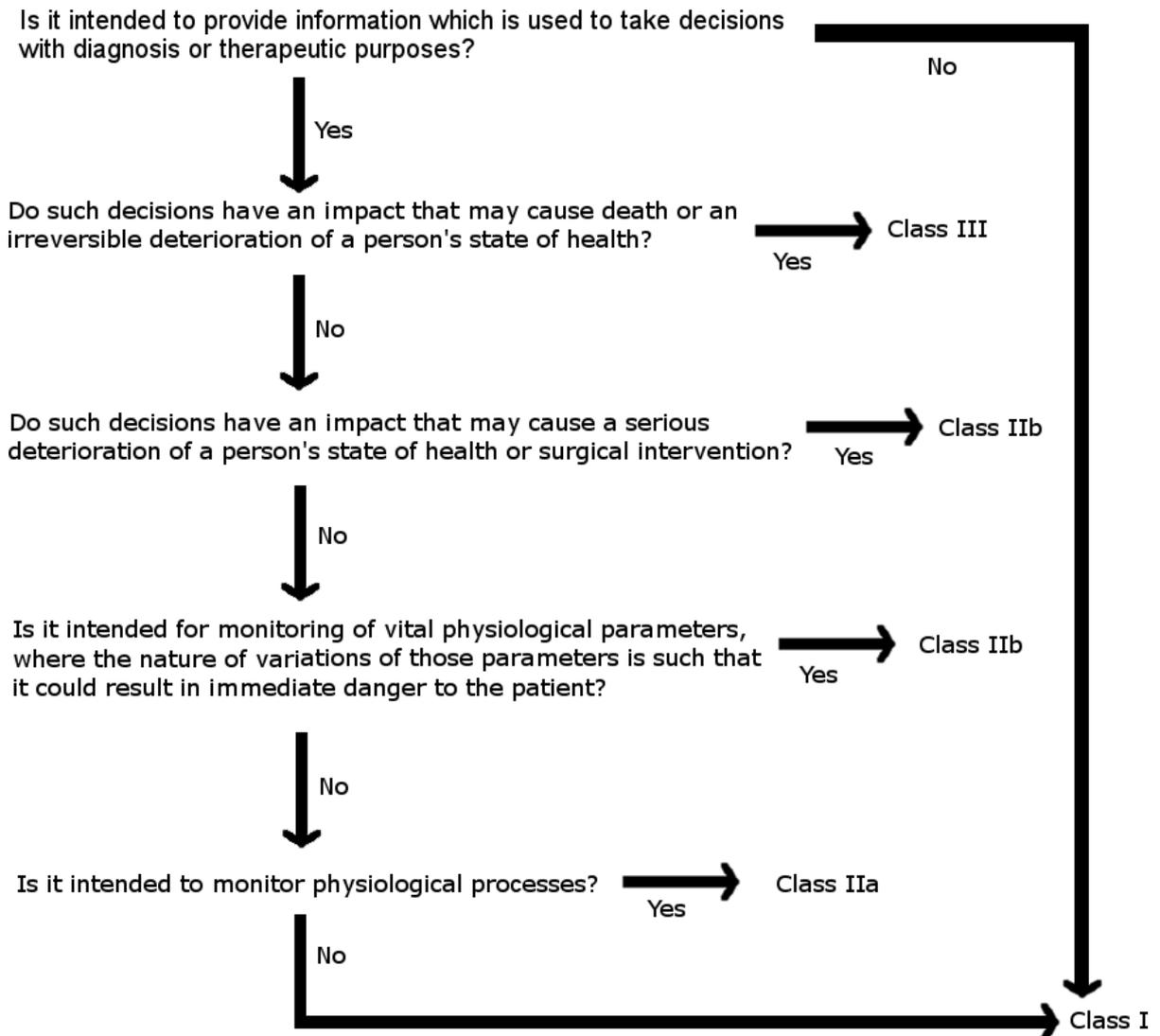
(Official Journal of the European Union 2017b)

## **4.2 Medical device classifications**

Medical device software (MDSW) is software that is intended to be used for a purpose outlined in the definition of a “medical device” in the MDR or an ‘in vitro medical device’ in the IVDR. Software which drives a device or influences its use, falls within the same class as the device itself. If the software is independent of any other device, it will be classified on its own. The application of the classification rules is based on the intended purpose of the MDSW. (Medical Device Coordination Group 2019)

### **4.2.1 Medical device classifications under MDR**

MDR divides medical devices into four different classes. These classes are I, IIa, IIb and III. (Official Journal of the European Union 2017a) MDSW’s class can be determined by following the steps presented in Figure 1, in cases where the only medical purpose of the MDSW is not driving a device or influencing the use of a hardware medical device (Medical Device Coordination Group 2019).



**Figure 1** MDSW classification under the MDR

#### 4.2.2 In vitro medical device classifications under IVDR

IVDR divides in vitro medical devices into four classes. These classes are A, B, C and D. Classification of a MDSW can be determined based on its intended use according to Annex VIII of IVDR. If a MDSW fits multiple classifications, the more severe classification stands. Class A is the least severe classification, while class D is the most severe. (Official Journal of the European Union 2017b)

“Devices intended to be used for the following purposes are classified as class D:

- detection of the presence of, or exposure to, a transmissible agent in blood, blood components, cells, tissues or organs, or in any of their derivatives, in order to assess their suitability for transfusion, transplantation or cell administration
- detection of the presence of, or exposure to, a transmissible agent that causes a life-threatening disease with a high or suspected high risk of propagation
- determining the infectious load of a life-threatening disease where monitoring is critical in the process of patient management” (Official Journal of the European Union 2017b)
- “blood grouping, or to determine foeto-maternal blood group incompatibility, or for tissue typing to ensure the immunological compatibility of blood, blood components, cells, tissue or organs that are intended for transfusion or transplantation or cell administration, when intended to determine any of the following markers” (Official Journal of the European Union 2017b):
  - “ABO system [A (ABO1), B (ABO2), AB (ABO3)]
  - Rhesus system [RH1 (D), RHW1, RH2 (C), RH3 (E), RH4 (c), RH5 (e)]
  - Kell system [Kell (K)]
  - Kidd system [JK1 (Jka), JK2 (Jkb)]
  - Duffy system [FY1 (Fya), FY2 (Fyb)]”

Devices are classified as class C if they are intended for blood grouping, or for “tissue typing to ensure the immunological compatibility of blood, blood components, cells, tissue or organs that are intended for transfusion or transplantation or cell administration” (Official Journal of the European Union 2017b). In addition, devices intended for any purpose listed in attachment 3 are classified as class C.

Also, devices intended to be used for self-testing are classified as class C, except for devices intended “for the detection of pregnancy, for fertility testing and for determining cholesterol level, and devices for the detection of glucose, erythrocytes, leucocytes and bacteria in urine, which are classified as class B” (Official Journal of the European Union 2017b). Devices that are controls without assigned qualitative or quantitative value are also classified as class B. For classification rules for devices belonging to class A, see attachment 4. Devices not covered by any of the other classification rules presented by the IVDR are classified as class B. (Official Journal of the European Union 2017b)

### 4.3 MDR conformity assessment procedures

All medical devices must go through a conformity assessment process before being placed on the market or put into service. Devices of different classes have different requirements for their conformity assessments. Generally, the conformity assessment for devices of class I should be carried out under the sole responsibility of the manufacturer. Devices of the other classes as well as some specific types of class I devices need to be assessed by a notified body. Notified body means a conformity assessment body designated in accordance with the MDR. Custom made or implantable devices might have different requirements for their conformity assessment procedures, all of which are not depicted here. (Official Journal of the European Union 2017a)

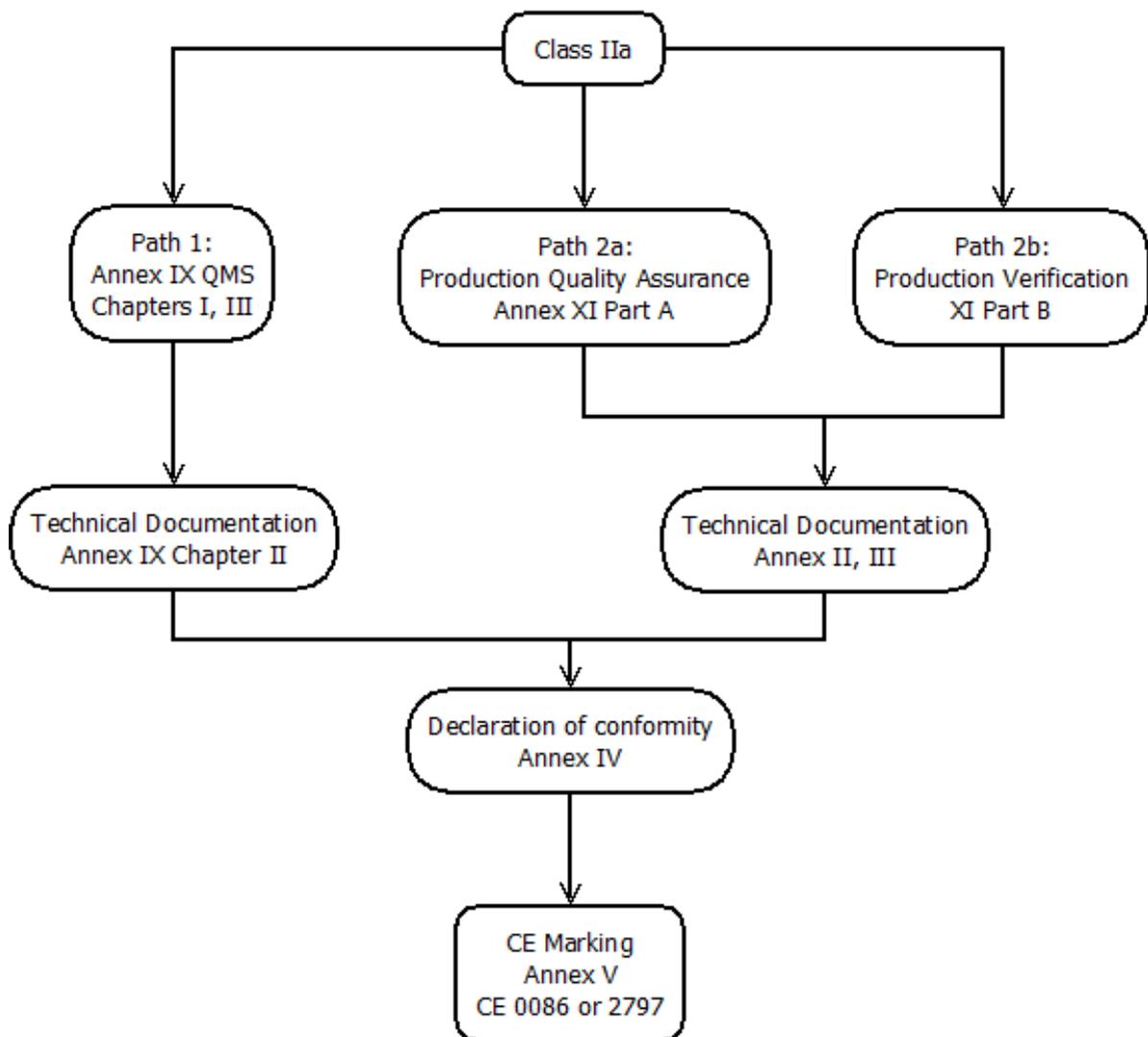
#### 4.3.1 Class I

Manufacturers of class I devices that are not custom-made or investigational devices, must draw up technical documentation set out by the MDR Annexes II and III, and then declare the conformity of their product. The technical documentation involves device description and specification, including variants and accessories, as well as documentation on post-market surveillance. If the device is to be placed on the market in sterile condition, has a measuring function, or is a reusable surgical instrument, the manufacturer must also apply some elements of the conformity assessment based on a quality management system or conformity assessment based on product conformity verification processes. The involvement of notified bodies in these cases is limited to ensuring conformity considering the aspects of the product that prompted the notified body assessment. (Official Journal of the European Union 2017a)

Manufacturers of custom-made devices, or their authorized representatives must draw up a statement containing information on the manufacturer and the device. The declaration of conformity as well as this statement must be kept at the disposal of the relevant authorities for at least 10 years, or in the case of implantable devices 15 years. (Official Journal of the European Union 2017a)

#### 4.3.2 Class IIa

Manufacturers of class IIa devices, other than custom-made or investigational devices, can choose one of three paths, depicted in Figure 2, through the conformity assessment process, all of which involve some form of notified body assessment. (Official Journal of the European Union 2017a)



**Figure 2** Conformity assessment paths for class IIa devices, according to BSI Group (2021)

Path 1:

“The manufacturer shall establish, document and implement a quality management system as described in Article 10(9) and maintain its effectiveness throughout the life cycle of the devices

concerned...The manufacturer must lodge an application for assessment of its quality management system with a notified body.” (Official Journal of the European Union 2017a) This application must include information on the manufacturer and the product, a draft of a declaration of conformity, as well as technical documentation set out by the MDR Annexes II and III. The notified body then audits the quality management system and technical documentation. The manufacturer must also give authorisation to the notified body to carry out audits and supply it with relevant information. The manufacturer or its authorised representative must keep at the disposal of relevant authorities the declaration of conformity, documentation on the quality management system, documentation on any changes to the quality management system, and decisions and reports from the notified body. (Official Journal of the European Union 2017a)

#### Path 2a:

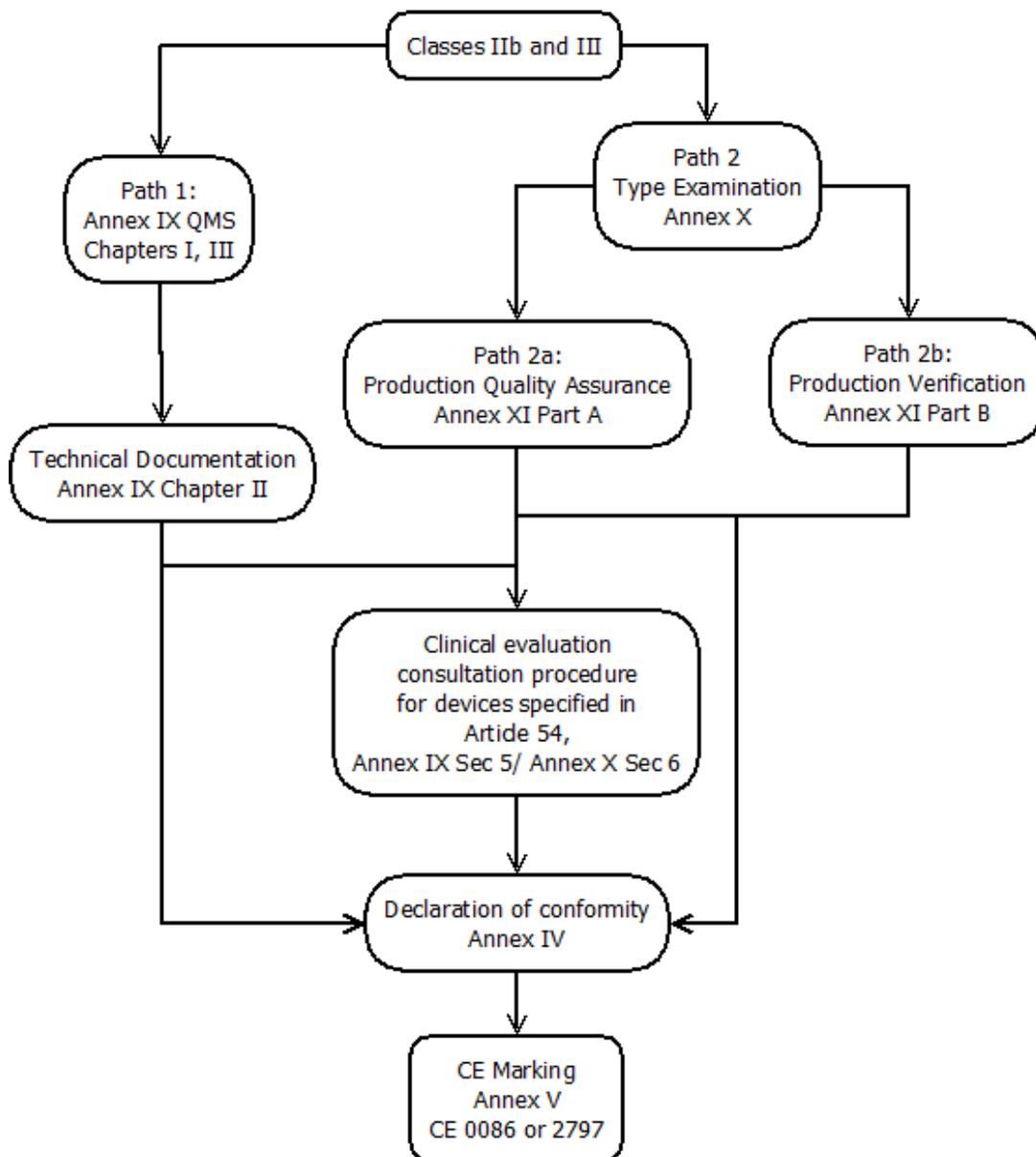
The manufacturer must draw up the technical documentation set out in Annexes II and III. The manufacturer must ensure and declare the devices conformity with the technical documentation and the MDR. A notified body must audit the quality management system of the manufacturer and assess the technical documentations conformity to the MDR. If the quality management system passes the audit, the notified body will issue an EU quality management system certificate. The manufacturer or its authorised representative must keep at the disposal of relevant authorities the declaration of conformity, the technical documentation, and the quality management system certificate. (Official Journal of the European Union 2017a)

#### Path 2b:

The manufacturer must draw up the technical documentation set out in Annexes II and III. The manufacturer must ensure and declare the devices conformity with the technical documentation and the MDR. A notified body will verify the devices conformity to the MDR by testing every product or every batch in case of some types of devices, individually. The notified body will affix or have affixed its identification number on each approved device and draw up an EU product verification certificate. The manufacturer or its authorised representative must keep at the disposal of relevant authorities the declaration of conformity, the technical documentation, and the product verification certificate. (Official Journal of the European Union 2017a)

### 4.3.3 Class IIb and class III

Manufacturers of class IIb or class III devices, much like those of class IIa devices, other than custom-made or investigational devices, can choose one of three paths, depicted in Figure 3. These paths through the conformity assessment process do however differ somewhat from those available for class IIa device manufacturers. (Official Journal of the European Union 2017a)



**Figure 3** Conformity assessment paths for class IIb and III devices, based on BSI Group (2021)

#### Path 1:

Path 1 is identical to Path 1 for class IIa devices, with the exception that depending on the device, the notified body might have to transmit some of the documents delivered to them on to the Commission and receive scientific opinion from experts. This is called the clinical evaluation consultation procedure. If the notified body opposes any of the expert opinions they receive, they must document their reasoning behind the decision. Also, for class III devices the surveillance assessment performed by the notified body also includes a test of the approved parts and/or materials that are essential for the integrity of the device. Finally, the manufacturer or its authorised representative must keep at the disposal of relevant authorities the declaration of conformity, documentation on the quality management system, documentation on any changes to the quality management system, and decisions and reports from the notified body, including the additional documents produced in the instances where clinical evaluation consultation was necessary. (Official Journal of the European Union 2017a)

#### Path 2:

The manufacturer lodges an application for assessment with a notified body. The application includes information on the manufacturer and technical documentation on the device. The manufacturer must also “make a representative sample of the device production envisaged available to the notified body” (Official Journal of the European Union 2017a). The notified body will examine the application, including the technical documentation and the clinical evaluation report as a part of it, as well as the sample of device production. The notified body will document the results and if the device type conforms to the MDR, issue an EU type-examination certificate. The manufacturer gives the notified body authorisation to perform audits as a part of its task of surveillance. The manufacturer or its authorised representative must keep at the disposal of relevant authorities the technical documentation of the device, information on any changes made to the device type, and copies of the type-examination certificate, scientific opinions and reports and their additions/supplements. Additionally, the manufacturer must perform the tasks outlined in sections Path 2a or Path 2b. (Official Journal of the European Union 2017a)

#### Path 2a:

The manufacturer must ensure that a fitting quality management system for the manufacture of devices under assessment is implemented. The manufacturer must draw up a declaration of conformity, and lodge an application for assessment of its quality management system by a notified body. The application must include information on the manufacturer, the declaration of conformity, technical documentation of the device, documentation and relevant information on the quality management system, documentation and information on the manufacturer's post-market surveillance system, documentation and information on the clinical evaluation plan, and a copy of the EU type-examination certificate. The manufacturer must also give the notified body authorisation to perform audits as a part of its task of surveillance. For devices of class III this surveillance also includes checking that the quantities of approved produced or purchased raw material or crucial components corresponds to the quantities of finished devices. If the notified body decides the quality management system conforms to the MDR, an EU quality assurance certificate will be issued. In addition to the information outlined under section path 2, the manufacturer or its authorised representative must keep at the disposal of relevant authorities the declaration of conformity, documents on the quality management system, and decisions and reports from the notified body. (Official Journal of the European Union 2017a)

Path 2b:

Prior to the start of the manufacturing process, the manufacturer must prepare documents defining the manufacturing process. The manufacturer must also institute and keep up to date a post-market surveillance plan that includes a post-market clinical follow-up plan. A notified body will then individually verify the conformity, to the type-examination certificate and to the MDR, of every device manufactured. In addition to the information outlined under section path 2, the manufacturer or its authorised representative must keep at the disposal of relevant authorities an EU declaration of conformity. (Official Journal of the European Union 2017a)

#### **4.4 IVDR conformity assessment procedures**

All in vitro medical devices must go through a conformity assessment process before being placed on the market or put into service, except for in-house devices manufactured pursuant to Article 5(5) of the IVDR. The conformity assessment for most devices of class A can be carried out under the sole responsibility of the manufacturer, while devices of the other classes as well

as some specific types of class A devices need to be assessed by a notified body designated in accordance with the IVDR. Devices for companion diagnostics, depending on their class, have some additional requirements for their conformity assessment procedure. “Companion diagnostic devices mean devices which are essential for the safe and effective use of a corresponding medicinal product to identify...patients who are most likely to benefit from the corresponding medicinal product, or...likely to be at increased risk of serious adverse reactions as a result of treatment with the corresponding medicinal product” (Official Journal of the European Union 2017b). Devices for performance studies have their own separate set of requirements that are not considered in this bachelor’s thesis. (Official Journal of the European Union 2017b)

#### 4.4.1 Class A

Manufacturers of class A devices, other than devices for performance study, must draw up technical documentation set out in Annexes II and III of the IVDR, and issue a declaration of conformity referred to in article 17. For devices that are placed on the market in sterile condition, notified body assessment of the aspects relating to establishing and maintaining sterile conditions is also necessary. (Official Journal of the European Union 2017b)

#### 4.4.2 Class B

“Manufacturers of class B devices, other than devices for performance study...[must]...establish, document and implement a quality management system as described in Article 10(8) [of the IVDR], and maintain its effectiveness throughout the life cycle of the devices concerned” (Official Journal of the European Union 2017b). The manufacturer must then lodge an application for assessment of its quality management system with a notified body. The application must include information on the manufacturer and the device, a draft of an EU declaration of conformity, documentation and information on the quality management system, documentation and information on the manufacturers post-market surveillance plan and system, and information on the manufacturers performance evaluation plan. (Official Journal of the European Union 2017b)

The notified body will audit the quality management system and determine whether it meets the requirements set out by the IVDR. If the quality management system passes the audit, the notified body will issue an EU quality management system certificate. The manufacturer must also give the notified body authorisation to carry out audits and supply it with relevant information. The notified body also evaluates the technical documentation of the device, and its clinical evidence and performance evaluation. The manufacturer or its authorised representative must keep at the disposal of relevant authorities the EU declaration of conformity, documentation and information on the quality management system, information on any changes to the quality management system, the technical documentation of the device, and the decisions and reports from the notified body. (Official Journal of the European Union 2017b)

In cases concerning devices for self-testing or near-patient testing, the manufacturer must also follow some extra steps. The manufacturer must lodge an application for the assessment of the technical documentation with the notified body. The application must include test reports, an example of the device if applicable, data showing the suitability of the device in view of its intended purpose, and the information to be provided with the device on its label and instructions for use. The notified body will verify the compliance of the device with the IVDR and issue an EU technical documentation certificate. In addition to the forementioned information, manufacturers of devices for self-testing or near-patient testing must also keep available the information included in the application for the assessment of the technical documentation. (Official Journal of the European Union 2017b)

#### 4.4.3 Class C

Manufacturers of class C devices, other than devices for performance study, can choose one of two paths. (Official Journal of the European Union 2017b)

##### Path 1:

Path 1 is identical to the conformity assessment procedures for devices of class B, with the addition of surveillance performed by the notified body and some additions concerning companion diagnostics devices. The manufacturer must give the notified body authorisation to

carry out all the necessary audits regarding the quality management system implemented by the manufacturer. Manufacturers of companion diagnostics devices must lodge an application with the notified body for the assessment of the device's technical documentation, similarly to devices for self-testing or near-patient testing. When assessing the technical documentation of companion diagnostics devices, the notified body must consult a fitting medicinal product authority. The notified body must consider the scientific opinion they receive from the medicinal product authority consulted. Finally, if the notified body decides the device conforms to the IVDR, it will issue the EU technical documentation certificate. (Official Journal of the European Union 2017a)

#### Path 2:

The manufacturer lodges an application for assessment with a notified body. The application includes information on the manufacturer, technical documentation for the device, a representative sample of the device production envisaged, if practicable an example of the device, for self-testing or near-patient testing devices test reports and data showing its suitability in relation to its intended purpose, the information to be provided with the device on its label and its instructions for use. (Official Journal of the European Union 2017b)

The notified body then examines the application and assesses the technical documentation for conformity with the IVDR, and reviews the clinical evidence presented by the manufacturer. The notified body will carry out or arrange for the appropriate assessments and physical or laboratory tests. For companion diagnostics devices, the notified body must also seek the opinion of an external medicinal products authority and consider this opinion when making its decision. If the device conforms to the IVDR, the notified body will issue an EU type-examination certificate. The manufacturer or its authorised representative must keep at the disposal of relevant authorities the technical documentation of the device, information on any changes to the device type, and copies of the type-examination certificates, scientific opinions and reports and their additions or supplements. (Official Journal of the European Union 2017b)

The manufacturer must also ensure that a quality management system approved for the manufacture of the device is implemented. The manufacturer draws up an EU declaration of conformity. The manufacturer then must lodge an application for assessment of its quality

management system with a notified body. The application includes information on the manufacturer and the device, a draft of an EU declaration of conformity, documentation and information on the quality management system, documentation and information on the manufacturer's post-market surveillance plan and system, information on the manufacturer's performance evaluation plan, technical documentation of the product and a copy of the EU type-examination certificate. The notified body will audit the quality management system, and if the system ensures that the devices conform to the type-examination certificate and to the IVDR, it will issue an EU production quality assurance certificate. The manufacturer must also give the notified body authorisation to carry out audits and supply it with relevant information. (Official Journal of the European Union 2017b)

In addition to the information listed prior, the manufacturer or its authorised representative must keep at the disposal of relevant authorities the declaration of conformity, documentation on the quality management system, documentation on the manufacturer's post market surveillance system including the type-examination certificate, information on any changes to the quality management system, and decisions and reports from the notified body. (Official Journal of the European Union 2017b)

#### 4.4.4 Class D

Similarly, to manufacturers of class C devices, manufacturers of class D devices can choose one of two paths through the conformity assessment procedure.

##### Path 1:

The manufacturer establishes, documents, and implements a quality management system as described in Article 10(8) of the IVDR, and maintains its effectiveness throughout the life cycle of the devices concerned. The manufacturer must then lodge an application for assessment of its quality management system with a notified body. The application must include information on the manufacturer and the device, a draft of an EU declaration of conformity, documentation and information on the quality management system, documentation and information on the manufacturer's post-market surveillance plan and system, and information on the manufacturer's performance evaluation plan. The manufacturer also must give the notified body authorisation

to perform all necessary audits to continuously evaluate the quality management system. The notified body will audit the quality management system and determine whether it meets the requirements set out by the IVDR. If the quality management system passes the audit, the notified body will issue an EU quality management system certificate. (Official Journal of the European Union 2017b)

The manufacturer must also lodge an application for the assessment of the technical documentation on the device with the notified body. The notified body will examine the application, review the clinical evidence presented by the manufacturer, document its conclusions, and request an EU reference laboratory to verify the performance claims of the manufacturer. The verification includes laboratory tests. In some cases, the notified body must also consult relevant experts. (Official Journal of the European Union 2017b)

The notified body must give due consideration to the scientific opinion expressed by the EU reference laboratory and if applicable to the expert opinions acquired. If the scientific opinion of the reference laboratory is unfavourable, the notified body cannot decide to issue a certificate. In cases concerning devices for self-testing or near-patient testing, the manufacturer must also follow the same extra steps for such devices as depicted in the class B section. Also, manufacturers of companion diagnostics devices must follow the steps concerning manufacturers of such devices depicted under the class C path 1 section. If the decision of the notified body is that the device conforms to the IVDR, it will issue an EU technical documentation assessment certificate. (Official Journal of the European Union 2017b)

The manufacturer or its authorised representative must keep at the disposal of relevant authorities the EU declaration of conformity, the documentation and information on the quality management system, information on any changes to the quality management system, the technical documentation of the device, and the decisions and reports from the notified body. (Official Journal of the European Union 2017b)

Path 2:

Path 2 is identical to the path 2 for class C devices, with the exceptions that the notified body assessment based on type-examination involves requesting an EU reference laboratory to verify

the performance claims made by the manufacturer and in certain cases consulting relevant experts. Additionally, the notified body assessment based on production quality assurance involves the requirement for the manufacturer to carry out tests on each manufactured batch of devices and forward to the notified body reports on those tests. The manufacturer must also make samples of manufactured devices available to the notified body, and the notified body or the manufacturer must also send samples to an EU reference laboratory. The manufacturer may place the devices on the market if an agreed time frame has passed and no decision opposing it has been communicated by the notified body. (Official Journal of the European Union 2017b)

#### **4.5 Data regulation in the EU**

Since the fundamental principle with AI-driven technologies is that they need a lot of data for training the AI (Santosh 2020), data related regulations are of critical importance to AI product development. REGULATION (EU) 2016/679 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 27 April 2016 on the protection of natural persons with regard to the processing of personal data and on the free movement of such data, and repealing Directive 95/46/EC (General Data Protection Regulation), is a very significant regulation when it comes to AI in the EU. The EU's General Data Protection Regulation (GDPR) can be seen as a strong policy response to new data utilizing technologies, such as DLNNs. The GDPR brings many responsibilities for data controllers to instil data protection rights for individuals (George, Reutimann, and Tamò-Larrieux 2019).

The GDPR is the prime example of regulatory action taken by a sovereign state federation to prevent unethical data usage and protect individuals. In the EU, GDPR has a lot of influence over the development of software-intensive technologies, especially AI. GDPR compliance is a must for companies, as failure to comply is heavily sanctioned. Companies should aim towards GDPR-compliance by-design, for example by implementing GDPR-compliant requirements engineering. (Tamburri 2020)

The GDPR was introduced to bring up to date and reform older EU regulations introduced to protect personal data of EU citizens. It establishes new laws limiting the processing of personal data, bringing new rights to individuals. Under the GDPR handling health data has more strict

rules than many other categories as data, as it is considered a more sensitive category of data. These stricter rules and conditions for example limit providing access to the data to third parties. (Lopes, Guarda and Oliveira 2020).

The GDPR outlines different rules and responsibilities for different entities based on their relation to the data in question. Two important such entity types are the controllers and processors:

“‘controller’ means the natural or legal person, public authority, agency or other body which, alone or jointly with others, determines the purposes and means of the processing of personal data; where the purposes and means of such processing are determined by Union or Member State law, the controller or the specific criteria for its nomination may be provided for by Union or Member State law;” (Official Journal of the European Union 2016)

“‘processor’ means a natural or legal person, public authority, agency or other body which processes personal data on behalf of the controller;” (Official Journal of the European Union 2016)

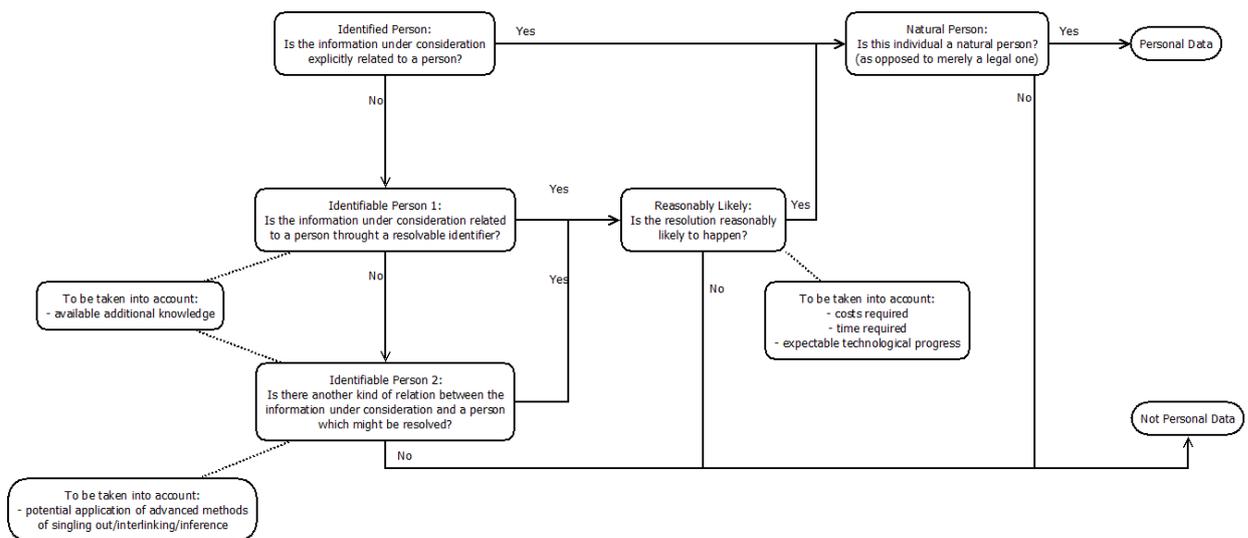
#### 4.5.1 Personal data

The GDPR applies to the processing of personal data wholly or partly by automated means and to the processing of personal data which form part of a filing system or are intended to form part of a filing system by other than automated means (Official Journal of the European Union 2016).

“‘personal data’ means any information relating to an identified or identifiable natural person (‘data subject’); an identifiable natural person is one who can be identified, directly or indirectly, in particular by reference to an identifier such as a name, an identification number, location data, an online identifier or to one or more factors specific to the physical, physiological, genetic, mental, economic, cultural or social identity of that natural person;” (Official Journal of the European Union 2016)

As GDPR only applies to the processing of personal data, for understanding the scope of the regulation it is necessary to know what kind of data is considered personal data. This distinction

between personal and non-personal data can however be difficult to make in practice, as many factors, such as data anonymization and current technologies available for deanonymization must be considered. Differing interpretations on the subject by various supervisory authorities further reduces the clarity around what constitutes personal data. (Finck, Pallas 2020) Figure 4 depicts an assessment scheme that can be used to gage whether data is personal or not under the GDPR.



**Figure 4** Assessment scheme for determining whether data is personal or not, based on Fink and Pallas (2020)

#### 4.5.2 Right to explanation

The existence and the extent of the right to explanation of automated decision making under the GDPR was widely analysed and debated in literature (e.g., Goodman and Flaxman 2017; Wachter, Mittelstadt and Floridi 2017; Selbst and Powles 2017) until data protection authorities released extensive guidance clarifying the hotly contested topic. The Article 29 Data Protection Working Party (A29WP) published a document called “Guidelines on Automated Individual Decision-Making and Profiling” detailing the subject in October 2017. While these guidelines are nonbinding, they do function as a reference point for how the EU member states should interpret the GDPR. The A29WP’s guidance brought much needed clarity to the “right to explanation” consisting of a collection of rights outlined by the GDPR. These rights are the

right to be informed, the right to obtain human intervention and the right to challenge a decision. (Casey, Farhangi and Roland 2019; A29WP 2017a) Companies making decisions concerning a natural person based solely on automated processing, including profiling, which produces legal effects concerning him or her or similarly significantly affects him or her, must (Official Journal of the European Union 2016; A29WP 2017a):

- tell the data subject that they are engaging in this type of activity;
  - provide meaningful information about the logic involved; and
  - explain the significance and envisaged consequences of the processing”
- (A29WP 2017a)

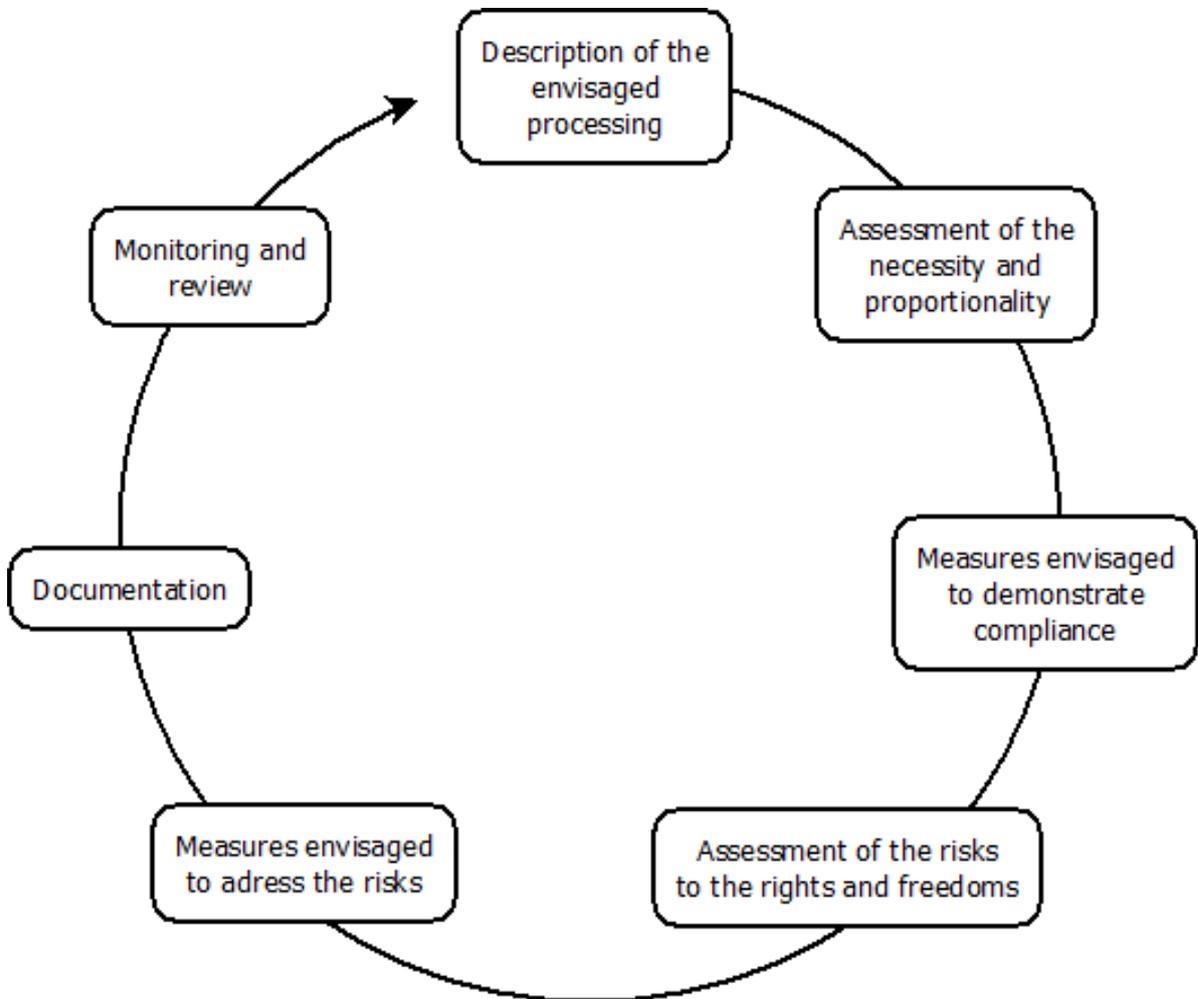
The A29WP (2017a) acknowledges the complexity of machine-learning applications and the difficulty understanding how exactly an automated decision-making process or profiling works, and further clarifies the extent of meaningful information that must be provided. The information provided must be comprehensive enough for the data subject to understand the reasons behind the decision. The controller has to provide meaningful information about the logic involved, but a complex explanation of the algorithms involved in the decision-making process, or disclosure of the full algorithm is not necessary.

The A29WP (2017a) also more specifically outlines what is considered fully automated processing. For the processing not to be considered automated, the controller must ensure that the human involvement and oversight involved in the decision-making during the processing is meaningful and carried out by someone with the authority and competence to change the decision.

#### 4.5.3 Data Protection Impact Assessment

The GDPR introduces the obligation to perform Data Protection Impact Assessments (DPIAs) if data processing is likely to result in a high risk (Demetzou 2019). A DPIA is a process that describes the processing of data and assesses its necessity and proportionality and helps manage the risks to the rights and freedoms of a natural person resulting from it. The DPIA is a process for developing and demonstrating compliance. (A29WP 2017b) The DPIA’s structure and form is not precisely defined by the EU data protection law, but it should be an iterative process,

alike to the one depicted in Figure 5, applying to all stages of a system's life cycle (Casey, Farhangi and Roland 2019).



**Figure 5** The iterative DPIA process according to Casey, Farhangi and Roland (2019)

As the need for DPIAs is based on whether the processing is likely to result in a high risk, it is important to understand what high risk means within the GDPR. When determining whether a risk is high, both the severity of the risk and its likelihood to occur must be considered. There is no solid, applicable definition for what constitutes a high risk within the EU data protection law. Instead, the legislature limits itself to only providing guidance on what could be considered highly risky. (Demetzou 2019) Some cases where a DPIA is mandatory are (Official Journal of the European Union 2016):

- “a) a systematic and extensive evaluation of personal aspects relating to natural persons which is based on automated processing, including profiling, and on which decisions are based that produce legal effects concerning the natural person or similarly significantly affect the natural person;
  - (b) processing on a large scale of special categories of data referred to in Article 9(1), or of personal data relating to criminal convictions and offences referred to in Article 10; or
  - (c) a systematic monitoring of a publicly accessible area on a large scale.”
- (Official Journal of the European Union 2016)

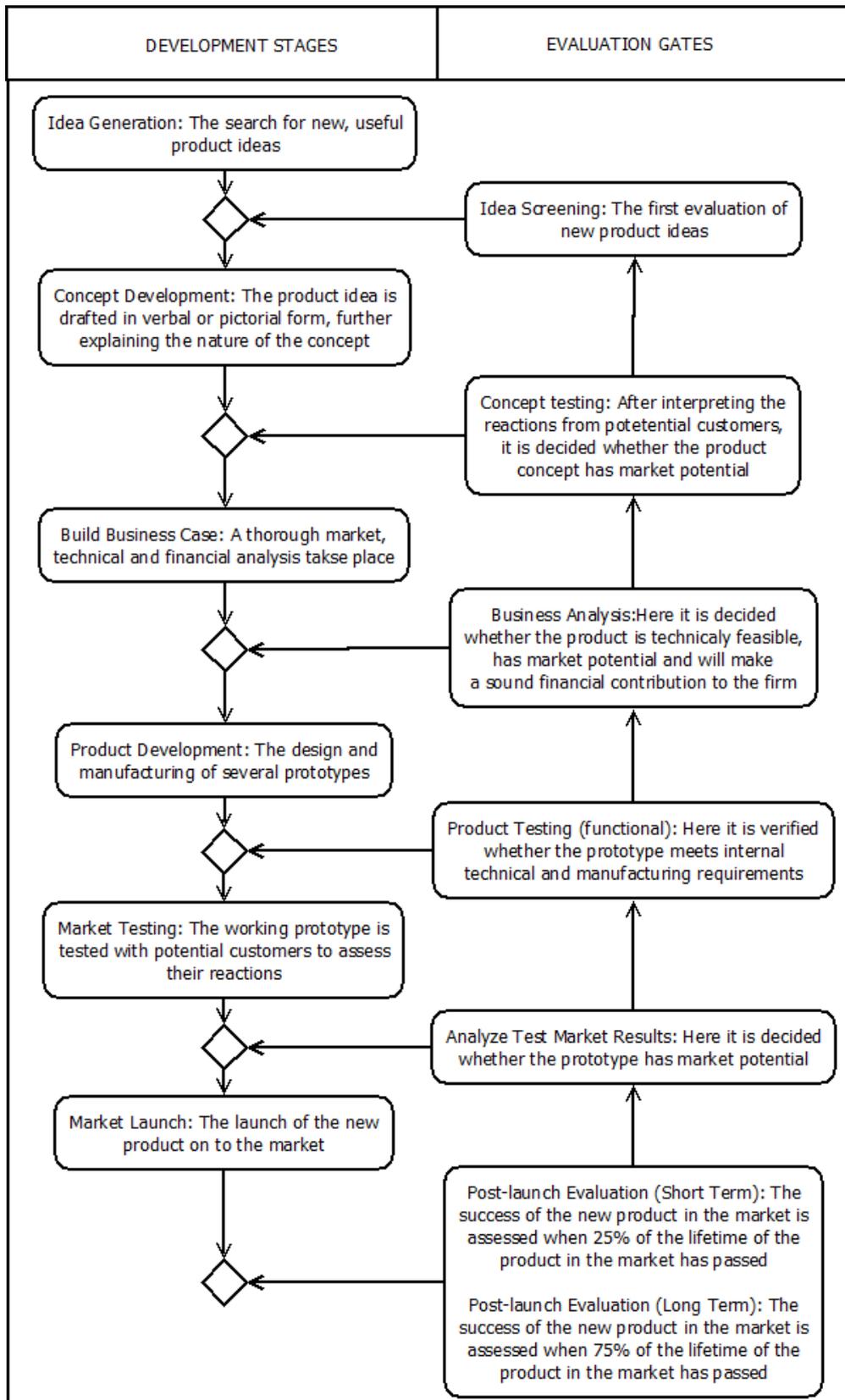
As health data is considered a special category of data, most healthcare products handling personal data can be expected to require DPIAs. In instances where it is not obvious if a DPIA is mandatory, it is recommended that a DPIA is always carried out, because DPIAs can help data controllers ensure compliance with the GDPR (A29WP 2017b).

## **5 NEW PRODUCT DEVELOPMENT PROCESS AND REGULATIONS**

### **5.1 New product development process**

The new product development (NPD) process includes the activities that a company performs in a sequence to conceive, design, and sell a product. The NPD process is complex and can include different steps in different organizations. (Battistoni, Colladon, Scarabotti and Schiraldi 2013) Following a structured development process within a company with predetermined objectives and milestones can reduce the time consumed by rework and modifications (Kessler and Chakrabarti 1999, cited by Harmancioglu, McNally, Calantone and Durmusoglu 2007). However, flexibility in product development through planned deviations from the formal process model when appropriate can increase the profitability of the NPD efforts furthermore (Cooper 1996).

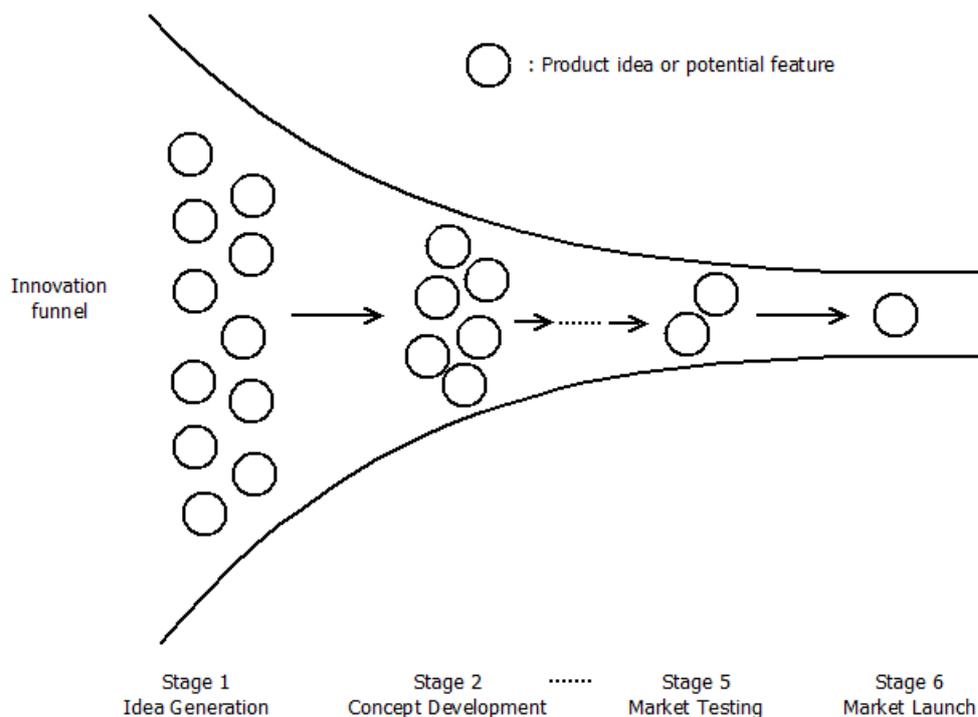
Tzokas, Hultink and Hart (2004) presents an NPD process model, which includes six development stages with evaluations alongside each stage. The purpose of the evaluations is to determine whether the new product should proceed further into development or be eliminated. The six development stages are the generation of new product ideas, the development of an initial product concept, an assessment of its business attractiveness, the actual development of the product, testing it within the market, and the actual launch of the product in the marketplace. This NPD process model depicted in Figure 7 is used in this bachelor's thesis to communicate the regulatory considerations necessary during NPD and the phase in which the considerations need to be made.



**Figure 6** The NPD process according to Tzokas, Hutlink et al. (2004)

The evaluation gates in this NPD process model are akin to the stage gates as described by (Cooper 1990) and serve the purposes of eliminating unprofitable NPD projects, ideas or solutions before more resources are wasted on them in the later stages, functioning as a part of a selectionism strategy mentioned by Wang (2010). With a selectionism strategy depicted in Figure 5, multiple ideas enter the early stages of product development, but only the best ones make it through all the evaluation gates and find their way to the market.

Each development stage is more expensive than the preceding one. Risk and amount of resources spent on failing NPD projects is reduced by eliminating unpromising ideas after only the less costly stages have been completed. Commitment to an idea increases gradually as the estimated risk of failure decreases based on success in each stage as the development moves forward. (Cooper 1996) A multitude of different obstacles in NPD can prevent successful commercialization at the end of the NPD process, and one of them is regulatory compliance (Guimaraes & Paranjape 2019). To increase the chances of successful and profitable commercialization of new products, regulations should be considered at all stages and stage gates of the product development process.



**Figure 7** Selectionism for R&D projects, based on Wang (2010) and Tzokas, Hutlink et al. (2004)

## **5.2 Idea generation and idea screening**

A wide variety of tools and methods exist for the purpose of enabling efficient and productive idea generation for companies. The tools applicable and most beneficial are individual to each company, so no single always applicable formula for the idea generation stage can be presented. The goal of the idea generation phase is to generate ideas that can be turned into profitable products through the following stages of product development. (Sowrey 1990) As the goal of the idea generation phase is generally to produce a lot of potential ideas to be then eliminated or selected for further development, limiting the creativity of participants by putting too much emphasis on limiting factors, such as regulations, might be counterproductive.

The idea screening is then performed to recognize and select the best ideas from the pool of ideas generated, enabling the actual implementation of the ideas selected (Rietzschel, Nijstad et al. 2010). Disregarding unpromising ideas in favour of better ones is critical for efficient allocation of resources. There are multiple ways to go about this section process, but a common factor with many approaches is considering the ideas' feasibility in one way or another (Onarheim, Christensen 2012; Rietzschel, Nijstad and Stroebe 2010; Soukhoroukova, Spann and Skiera 2012). The regulations concerning the product or feature idea can affect its feasibility greatly, and thus should be taken into consideration when selecting or eliminating ideas. If regulations clearly make the idea unfeasible, there is no point pursuing it further.

## **5.3 Concept development and concept testing**

Product concept development involves two fundamental design phases. These are product definition and product customization. Product definition phase aims to define a generic product platform and the relevant family of products. Design alternatives can also be established at this stage. During the product customisation phase, specific customer information is transferred into the product platform defined during the product definition phase. The results of the product concept development stage can be compiled into a list of specifications and target values for the product. (Chen, Khoo and Yan 2005)

During the transition to the 21st century's competitive global market, it became increasingly important for companies to focus on customer needs during product development. This shift in focus during NPD was realized across industries. (Khoo, Chen and Yan 2002) Successful concept development stage ensures the existence of the presumed customer need on the market the product concept is attempting to satisfy. This is achieved through the product definition and customization phases. During both these phases, regulations should be considered, as that helps make the resulting list of product specifications more realistic. If the product concept cannot satisfy both the customer needs and regulations in place, it should not make it through the concept testing evaluation gate.

Regulations can also add to the list of product specifications or target values, as they can impose requirements on the product that need to be satisfied. The GDPR might for example require some of the data used to be handled in specific ways, or the MDR might impose safety and quality requirements on the product that otherwise might not have been included in the product's target values. At the concept evaluation stage gate, the regulatory compliance of the product specifications should be investigated and ensured.

#### **5.4 Business case building and business analysis**

During the business case building phase, the product and its market is analysed thoroughly from a technical and a financial perspective. The corresponding business analysis stage gate evaluates whether the product is technically feasible and has market potential. (Tzokas, Hultink et al. 2004) When considering the market and competitors the device classification and certifications might be important to consider.

If a competitor has a product with similar features, but it cannot be sold to be used for some purposes as it lacks the needed certifications, there could possibly still be enough room on the market for the product being developed. If it seems feasible to get the certifications the competitor is lacking, entering the market with these certifications could be a source of competitive advantage.

The regulations can add to the technical requirements the product has to fulfil. This should be considered at the business analysis stage gate. When it comes to the technical feasibility of the product and its features, regulatory compliance is one of the most important determining factors, as if it is not achievable, the product cannot be sold legally.

### **5.5 Product development and functional product testing**

The product development phase of the NPD process involves designing and manufacturing prototypes for functional testing (Tzokas, Hultink et al. 2004). As all EU conformity assessment procedures for all medical device classes involve drawing up technical documentation for the device as depicted in the MDR or the IVDR, it is sensible to produce documentation fitting to these requirements as a part of the product development phase. Some conformity assessment procedures also require documentation of testing and clinical evidence to be produced by the manufacturer. In these cases, testing done by the manufacturer should also be documented in a manner which enables use of the documentation during the conformity assessment of the device. If the device classification is such that a quality management system must be implemented and documented by the manufacturer, this should also be done as a part of the product development stage.

The functional product testing should in addition to ensuring the prototypes produced meet the manufacturers internal technical and manufacturing requirements, make sure that the requirements set out by the devices corresponding EU medical device regulations are also satisfied. This involves ensuring that the quality management and technical requirements set out by the regulations are fulfilled.

The time it takes to go through the conformity assessment procedure of medical devices depends on the device classification and path selected through the procedure as well as the notified body performing the assessment and their availability. The covid-19 pandemic has recently affected the availability of notified bodies across Europe. Notified bodies are not able to carry out on-site audits which are a mandatory part of some conformity assessment procedures, likely impacting the time it takes to get certifications. For example, a survey conducted in 2020 by the EU Commission concluded that for new applications for COVID-19

related class IIb devices under Annex IX or XIA of the MDR, with most notified bodies applicable the assessment process takes three to twelve months. (Directorate-General for Communication 2020b)

As the duration of the assessment can vary greatly, depending on price of the assessment, confidence in the products potential, and launch date goal, the application should be done as soon as possible. This way the risk of unnecessary delays to the market launch caused by a prolonged assessment process can be minimized.

For devices that utilize data, DPIAs might be mandatory starting during the product development phase. When developing any device that processes data, going through the DPIA process at least once can help determine whether further DPIAs are necessary.

## **5.6 Market testing and analysing market testing results**

At the market testing stage, a working prototype is tested with potential customers. The customer reaction is then used to predict the market potential of the product. (Tzokas, Hultink et al. 2004). If the reception is positive, proceeding to perform the market launch is next. The market testing must be done in a way that conforms to regulations. If the conformity assessment process has not been finished yet, the product cannot be tested with customers in its full functionality.

The GDPR limits the ways market testing data can be collected and processed. All data processing performed must be done in accordance with the GDPR. This must be kept in mind when planning market testing as well as when analysing the market testing results.

Testing the prototype might for example reveal the need for further development of the device's user interface, which is grounds to return to the previous phase of the product development until the improvements have been made. Testing with potential customers can also be performed during the product development phase for purposes such as improving usability of the product. (Lim, Stolterman and Tenenberg 2008) The goal of the earlier phases of the NPD process should be to ensure no major changes need to be made this late in development, as that delays the schedule and increases costs.

If changes must be made, and a notified body assessment for the product is already under way, the notified body must be informed of the planned changes. This can delay the conclusion of the assessment process and increase the total cost of assessment.

### **5.7 Market launch and post-launch evaluations**

Before the market launch all the necessary conformity assessment steps must be completed. For some device classes implementing a post-market surveillance system for the product is mandatory. This surveillance must be planned as a part of the device's technical documentation for the conformity assessment and put to practice during and after the market launch. (Official Journal of the European Union 2017a)

Post-launch evaluations are performed to assess the success of the product (Tzokas, Hultink et al. 2004). If any changes are made to the product or its manufacturing, the notified body that assessed its conformity must be informed as specified in contractual arrangements between the notified body and the manufacturer (Official Journal of the European Union 2017a, 2017b). Re-certification of each certificate must be performed within the timeframes specified by the regulations. Future changes to regulations must also be kept an eye on, and any changes must be handled appropriately.

## 6 CONCLUSIONS

AI solutions are expected to bring new possibilities for the healthcare industry. AI can be used to improve the efficiency of healthcare as well as improve the quality and availability of services provided by healthcare providers. This bachelor's thesis investigates the regulations affecting the development and implementation of AI solutions for healthcare in the EU. The purpose of this research is to compile the relevant requirements set out by these regulations and describe their effect on the NPD-process. This research answers the following questions:

Q1: How AI in medical devices is regulated in 2021 in the EU?

Q2: What is required to certify a medical device incorporating AI?

Q3: How should these regulations be considered during product development?

As practically all AI solutions are reliant on data in one form or another, regulation of data collection and processing widely affects AI products and their development. EU has put in place, compared to other regions of the world, strict data protection regulations aiming to protect citizens' privacy. The GDPR limits the legal use of data and imposes the need to perform DPIAs when planning to perform some specific kinds of data processing or processing specific categories of data. DPIAs are mandatory for most companies developing AI solutions for healthcare, as health data is considered a special category of data. To ensure compliance of data processing with the GDPR, performing DPIAs is recommendable even in instances where it might not be mandatory. The GDPR also provides subjects of automated individual decision-making with a collection of rights generally referred to as the right to explanation. This right to explanations limits some AI solutions for healthcare, as it imposes requirements on automated decision-making systems and the organizations using them.

Software medical products can be classified as medical devices and are regulated by the MDR and the IVDR. Medical devices are predominantly classified based on their intended use and inherent risk. Different device classifications lead to different requirements for the manufacturer and the conformity assessment procedures necessary to certify the product to sell or to put it to use. Sections 4.2, 4.3 and 4.4 of this bachelor's thesis detail the classification of medical devices and their conformity assessment procedures pursuant of certification. Compliance to the GDPR can be demonstrated by pursuing data protection seals or marks

through data protection certification mechanisms (Official Journal of the European Union 2016). However, unlike the medical device certification and CE-marking, these data protection seals or marks are not mandatory (Official Journal of the European Union 2016, 2017a, 2017b). Failure to conform to the GDPR will however, when discovered, lead to sizable fines (Official Journal of the European Union 2016).

Considering these regulations during multiple stages of the new product development process can be expected to improve the efficiency of the process as well as to reduce risks. The duration of the conformity assessment procedure for the device type under development must be taken into account when planning the development process and the market launch date.

The GDPR should be considered at least to some extent at all stages of the NPD process, other than idea generation. MDR or IVDR also affects all stages of development of devices that fall within the scope of each regulation. Considering these regulations during the early stages of development is mostly important to improve the efficiency of the NPD process, while during the later stages it is necessary to avoid legal trouble. Table 1 depicts the most important considerations to be made based on these regulations at each development stage and stage gate.

**Table 1** Considering regulations during product development

|                        |   |
|------------------------|---|
| Idea Generation        | -   |
| Idea Screening         | Elimination of clearly unfeasible ideas based on the GDPR and the relevant medical device regulations.  |
| Concept Development    | Product specifications produced must conform to the regulations. Target values must not conflict with the regulations.  |
| Concept Testing        | Product specifications conformity to the regulations must be investigated and ensured.  |
| Business Case Building | When analysing the market, competing products and manufacturers' regulatory situation relative to the product in development should be considered.              |
| Business Analysis      | When deciding whether the product is technically feasible, regulations should be taken into account. Regulations can add relevant requirements for the product. |

|                                  |   |
|----------------------------------|---|
| Product Development              | Documentation should be done in accordance with the regulations, as it is needed for the conformity assessment procedures under the MDR and the IVDR. DPIAs should be performed, as necessary. Applying for notified body assessment should be considered as early as possible for devices that need it, to avoid unnecessary delays in market launch.  |
| Functional Product Testing       | In addition to the manufacturers internal technical and manufacturing requirements, the product must also satisfy the technical and manufacturing requirements set by the regulations.  |
| Market Testing                   | Market testing must be performed in accordance with the regulations. Full functionality of medical devices cannot be tested unless the necessary certifications have already been acquired. Data must be collected in accordance with the GDPR.   |
| Analysing Market Testing Results | Data must be processed in accordance with the GDPR. If notified body assessment is already in progress, the notified body must be informed of any planned changes to the product. In these instances, the benefits of making the changes must be weighed against the costs and delays caused by the potentially extended notified body assessment process.  |
| Market Launch                    | All the conformity assessment procedures required must be completed before market launch. For products that require post market surveillance systems to be put in place, the surveillance systems must be implemented at launch.  |
| Post-Launch Evaluation           | If changes are to be made to the product or its manufacture post-launch, the notified body that assessed it must be informed in accordance with the contractual arrangements between the manufacturer and the notified body. Recertification for all certificates must be performed at timeframes specified by the regulations. Changes to regulations must be monitored, as they might require manufacturers to adapt. |

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## Appendix 1. Medical device definition under the MDR

“‘Medical device’ means any instrument, apparatus, appliance, software, implant, reagent, material or other article intended by the manufacturer to be used, alone or in combination, for human beings for one or more of the following specific medical purposes:

- diagnosis, prevention, monitoring, prediction, prognosis, treatment or alleviation of disease,
- diagnosis, monitoring, treatment, alleviation of, or compensation for, an injury or disability,
- investigation, replacement or modification of the anatomy or of a physiological or pathological process or state,
- providing information by means of in vitro examination of specimens derived from the human body, including organ, blood and tissue donations,

and which does not achieve its principal intended action by pharmacological, immunological or metabolic means, in or on the human body, but which may be assisted in its function by such means. The following products shall also be deemed to be medical devices:

- devices for the control or support of conception;
- products specifically intended for the cleaning, disinfection or sterilisation of devices as referred to in Article 1(4) and of those referred to in the first paragraph of this point.”  
(Official Journal of the European Union 2017a)

## Appendix 2. In vitro medical device definition under the IVDR

“‘In vitro diagnostic medical device’ means any medical device which is a reagent, reagent product, calibrator, control material, kit, instrument, apparatus, piece of equipment, software or system, whether used alone or in combination, intended by the manufacturer to be used in vitro for the examination of specimens, including blood and tissue donations, derived from the human body, solely or principally for the purpose of providing information on one or more of the following:

- (a) concerning a physiological or pathological process or state;
  - (b) concerning congenital physical or mental impairments;
  - (c) concerning the predisposition to a medical condition or a disease;
  - (d) to determine the safety and compatibility with potential recipients;
  - (e) to predict treatment response or reactions;
  - (f) to define or monitoring therapeutic measures.”
- (Official Journal of the European Union 2017b)

### Appendix 3. Intended purposes leading to class C classification under the IVDR

“Devices are classified as class C if they are intended;

- (a) for detecting the presence of, or exposure to, a sexually transmitted agent;
- (b) for detecting the presence in cerebrospinal fluid or blood of an infectious agent without a high or suspected high risk of propagation;
- (c) for detecting the presence of an infectious agent, if there is a significant risk that an erroneous result would cause death or severe disability to the individual, foetus or embryo being tested, or to the individual's offspring;
- (d) for pre-natal screening of women in order to determine their immune status towards transmissible agents;
- (e) for determining infective disease status or immune status, where there is a risk that an erroneous result would lead to a patient management decision resulting in a life-threatening situation for the patient or for the patient's offspring;
- (f) to be used as companion diagnostics;
- (g) to be used for disease staging, where there is a risk that an erroneous result would lead to a patient management decision resulting in a life-threatening situation for the patient or for the patient's offspring;
- (h) to be used in screening, diagnosis, or staging of cancer
- (i) for human genetic testing;
- (j) for monitoring of levels of medicinal products, substances or biological components, when there is a risk that an erroneous result will lead to a patient management decision resulting in a life-threatening situation for the patient or for the patient's offspring;
- (k) for management of patients suffering from a life-threatening disease or condition;
- (l) for screening for congenital disorders in the embryo or foetus;
- (m) for screening for congenital disorders in new-born babies where failure to detect and treat such disorders could lead to life-threatening situations or severe disabilities.” (Official Journal of the European Union 2017b)

#### Appendix 4. Intended purposes leading to class A classification under the IVDR

“The following devices are classified as class A:

- (a) products for general laboratory use, accessories which possess no critical characteristics, buffer solutions, washing solutions, and general culture media and histological stains, intended by the manufacturer to make them suitable for *in vitro* diagnostic procedures relating to a specific examination;
- (b) instruments intended by the manufacturer specifically to be used for *in vitro* diagnostic procedures;
- (c) specimen receptacles.” (Official Journal of the European Union 2017b)