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**From Regulation to Application: Insights into Medical  
Device Software Certification Under EU MDR in the Portuguese  
Context**

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***The dictionary is the only place that success comes before work.***

Vince Lombardi

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## Resumo

A história dos dispositivos médicos remonta a tempos antigos, quando os seres humanos começaram a desenvolver ferramentas para melhorar o diagnóstico e o tratamento de doenças. Com o avanço da ciência e da tecnologia, estes dispositivos evoluíram, passando de instrumentos mecânicos simples para soluções eletrônicas e, mais recentemente, para softwares que desempenham funções críticas em ambientes clínicos/hospitalares. A origem do software como dispositivo médico (Medical Device Software – MDSW) é um marco importante nesta trajetória, refletindo a crescente digitalização dos cuidados de saúde e a importância da automação e da análise de dados na prática clínica moderna. Este salto tecnológico, contudo, também trouxe novos desafios regulatórios, exigindo a adaptação dos regulamentos existentes para garantir a segurança e a eficácia destas novas ferramentas digitais.

Historicamente, a regulamentação de dispositivos médicos na Europa começou com a Diretiva de Dispositivos Médicos (Medical Device Directive – MDD), implementada em 1993. Durante décadas, a MDD serviu como o principal quadro regulatório para a avaliação e comercialização de dispositivos médicos no Espaço Económico Europeu. Contudo, com o tempo, tornou-se evidente que o aumento da complexidade e da diversidade dos dispositivos, incluindo os baseados em software, exigia uma revisão abrangente da regulamentação. Essa necessidade levou à introdução do Regulamento de Dispositivos Médicos (Medical Device Regulation – MDR), que entrou em vigor em Maio de 2021, substituindo a MDD. O MDR introduziu critérios mais rigorosos para a certificação de dispositivos médicos, especialmente em relação ao MDSW, reforçando a importância de uma supervisão mais robusta para lidar com os riscos inerentes a estes produtos.

Entre as novas características dos MDSW, destacam-se o uso de inteligência artificial e de machine learning, tecnologias que permitem uma análise mais avançada de dados médicos e a personalização dos cuidados de saúde. No entanto, estas inovações também levantam preocupações, sobretudo no que se refere à cibersegurança. Com a crescente conectividade dos dispositivos médicos, a proteção de dados e a integridade dos sistemas são questões críticas que devem ser abordadas pelas autoridades regulatórias para evitar que falhas de segurança comprometam a privacidade dos pacientes ou, em casos mais graves, causem danos físicos.

O crescimento do mercado de MDSW tem sido exponencial. Estima-se que este continue a se expandir, impulsionado pela procura crescente de soluções em saúde digital devido à pandemia do vírus COVID-19 e o envelhecimento da população. Os fabricantes de MDSW estão sob pressão para garantir que seus produtos cumpram as normas do MDR, mas, ao mesmo tempo, enfrentam dificuldades significativas, devido à complexidade dos requisitos regulamentares e à falta de clareza nas diretrizes.

Durante o meu estágio na Complear, tive a oportunidade de lidar com diferentes tipos de MDSW e desenvolver estratégias regulatórias para empresas que operam neste setor. Esta experiência foi fundamental para o meu desenvolvimento profissional, mas também revelou uma série de desafios, especialmente no que diz respeito à qualificação e classificação de MDSW. Um dos problemas mais recorrentes foi a falta de guias claros para este primeiro passo da estratégia regulatória. Devido à ambiguidade das regulamentações, muitas vezes cabe à interpretação do regulador ou do fabricante decidir se um software deve ser qualificado como dispositivo médico e, em caso afirmativo, em que classe este deve ser enquadrado.

Diante desta lacuna regulatória, um método estruturado para a elaboração de estratégias regulatórias foi desenvolvido, com o objetivo de preencher essas lacunas interpretativas. O método proposto para a qualificação e classificação de MDSW é projetado para facilitar uma abordagem

sistemática para a regulamentação destes produtos, minimizando a ambiguidade e oferecendo orientações mais claras para os fabricantes. A estrutura pode ser dividida em três partes principais:

- A primeira parte envolve a **informação do produto**, onde o fabricante avalia o software em questão. Este passo é essencial para estabelecer uma compreensão clara e detalhada das características e do uso pretendido do software, o que formará a base para sua subsequente qualificação e classificação. Nesta fase, é crucial definir claramente o propósito médico do software, as suas funcionalidades e como interage com os dados dos pacientes.
- A segunda parte do método é o processo de **qualificação e classificação das funcionalidades**. Esta etapa consiste numa avaliação detalhada das funcionalidades identificadas na fase anterior, utilizando um questionário estruturado com doze perguntas direcionadas, divididas em três partes: propósito médico, ação sobre os dados e condição. Este questionário foi projetado para ajudar os fabricantes a avaliar de maneira mais objetiva se uma funcionalidade específica do software deve ser qualificada como dispositivo médico e, caso afirmativo, qual deve ser sua classificação regulatória.
- A terceira parte do método refere-se aos **cenários de classificação**. Uma vez que todas as funcionalidades individuais do MDSW tenham sido qualificadas e classificadas, o passo seguinte envolve a agregação dessas funcionalidades para avaliar o cenário de classificação mais adequado para o software como um todo, levando em consideração os objetivos estratégicos da empresa. Este processo é essencial para determinar se o software, quando todas as funcionalidades pretendidas são combinadas, se qualifica como um dispositivo médico nos termos do MDR e, em caso afirmativo, qual deve ser sua classificação.

Um exemplo desta abordagem é o caso de uma plataforma de telemedicina. Se o software apenas fornecer consultas por vídeo, não seria qualificado como um dispositivo médico. No entanto, se a plataforma incluir funcionalidades adicionais, como o monitorização em tempo real da função pulmonar do paciente, esta funcionalidade deve ser qualificada como um dispositivo médico. Estas incertezas e possíveis erros de qualificação/classificação ressaltam que há uma necessidade de uma abordagem mais abrangente e sistemática, tal como a desenvolvida.

Com o desenvolvimento deste método, surgiu outra questão pertinente: **Os MDSWs utilizados nos hospitais portugueses estão em conformidade com o MDR?** Depois de uma pesquisa extensa, a análise revelou que cerca de 70% (68,4%) dos MDSWs em uso não estão em conformidade com as novas regulamentações. Este resultado destaca a necessidade urgente de uma maior supervisão regulatória e de esforços coordenados para resolver as questões de conformidade, sublinhando a importância de uma adaptação contínua ao panorama regulatório em evolução.

O desenvolvimento deste método regulatório representa um avanço significativo tanto para os profissionais de Assuntos Regulatórios quanto para os fabricantes que procuram clareza na qualificação e classificação de MDSW. Ao fornecer uma abordagem estruturada para a avaliação funcional dos softwares, este método aborda as complexidades e ambiguidades inerentes ao processo regulatório, oferecendo aos fabricantes uma metodologia mais precisa para determinar o estado regulatório dos seus produtos. Isto facilita a conformidade com o MDR e agiliza o caminho para a autorização de comercialização, ao mesmo tempo que protege a saúde pública.

Além disso, a avaliação de conformidade dos MDSWs utilizados em hospitais portugueses revelou importante informação sobre o estado atual da adesão regulatória. Os resultados indicam que muitos desses softwares não cumprem os padrões estabelecidos pelo MDR, evidenciando uma lacuna na supervisão que as Autoridades Competentes que, atualmente, não possui recursos suficientes para

resolver completamente. Este cenário reforça a necessidade de um método regulatório mais rigoroso e de uma maior fiscalização dos MDSW no ambiente hospitalar.

Tendo esta informação, verifica-se que existe a necessidade de uma regulamentação mais rigorosa e de uma melhor execução para garantir a segurança e a eficácia dos MDSW. Considerando que tais softwares desempenham um papel central nos cuidados aos pacientes, é essencial manter elevados padrões para prevenir os riscos potenciais associados a softwares inadequados ou não conformes. Melhorar as práticas regulatórias não apenas salvaguardará o bem-estar dos pacientes, como também aumentará a confiança nas novas tecnologias da saúde, garantindo que todas as partes interessadas – pacientes, prestadores de serviços de saúde e órgãos reguladores – beneficiem de tecnologias mais seguras e eficazes.

Por fim, embora o método regulatório desenvolvido tenha proporcionado uma solução prática para a qualificação e classificação de MDSW, é essencial que ele seja **validado e testado** em diversos cenários para garantir a sua aplicabilidade a uma ampla gama de produtos de software. Além disso, seria benéfico explorar a integração de tecnologias de inteligência artificial e machine learning para automatizar partes do processo regulatório, aumentando a precisão e a eficiência das avaliações.

Este trabalho procura contribuir significativamente para a área de Assuntos Regulatórios, oferecendo uma solução estruturada para um problema complexo e em constante evolução. Convido o leitor a continuar a leitura desta dissertação para explorar em maior profundidade os desafios e soluções propostos para a regulamentação de softwares como dispositivos médicos, um campo em rápida expansão e de importância crescente para a saúde pública.

**Palavras-chave:** Estratégia Regulatória; Qualificação; Classificação; Abordagem Funcionalidade-a-Funcionalidade; Conformidade Regulatória

## Abstract

Medical devices are part of modern diagnosis and treatment, and the rapid advancement of technology has led to the emergence of software solutions designed to assist in managing various diseases and conditions. These software applications, when meeting specific criteria, are classified as Medical Device Software (MDSW) under the European Union's Medical Device Regulation (MDR). The increasing use of MDSWs has prompted regulatory authorities globally to scrutinize these digital tools more closely due to the potential risks they pose to patients and users. Consequently, MDSWs are subject to rigorous regulatory oversight to ensure they meet stringent safety and efficacy standards.

During my internship, I identified significant challenges in developing regulatory strategies for software due to the ambiguity and interpretive nature of existing guidelines and regulations. This ambiguity can lead to errors in the qualification and classification of software. To address this issue, I developed a regulatory strategy framework based on a feature-by-feature approach. This framework involves qualifying and classifying each feature individually, followed by grouping them to establish the software's classification scenarios. This method offers companies a clearer path for regulatory compliance, aligning with their resources and goals.

In applying this framework, I hypothesized that many MDSWs currently used in hospital settings may be misclassified or overlooked as medical devices. An assessment of 94 MDSWs used in Portuguese hospitals revealed that nearly 70% of those produced by Portuguese manufacturers are not compliant with MDR standards. This finding highlights a significant public health concern that warrants immediate attention and further investigation.

**Keywords:** Regulatory Strategy; Qualification; Classification; Feature-by-feature approach; Regulatory Compliance

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## Nomenclature

### Abbreviations

<b>Compear</b>	Compliance Tech, Sociedade Unipessoal Lda.
<b>ISO 13485:2016 + A11:2021</b>	ISO 13485

### Acronyms

<b>AI</b>	Artificial Intelligence
<b>CE</b>	Conformité Européene
<b>EU</b>	European Union
<b>eQMS</b>	Electronic Quality Management System
<b>eTD</b>	Electronic Technical Documentation
<b>FDA</b>	Food and Drug Administration
<b>GDPR</b>	General Data Protection Regulation
<b>IMDRF</b>	International Medical Device Regulators Forum
<b>IVD</b>	<i>In Vitro</i> Diagnostic
<b>IVDD</b>	<i>In Vitro Diagnostic</i> Medical Devices Directive
<b>IVDR</b>	<i>In Vitro Diagnostic</i> Medical Device Regulation
<b>MDCG</b>	Medical Device Coordination Group
<b>MD</b>	Medical Devices
<b>MDD</b>	Medical Device Directive
<b>MDR</b>	Medical Device Regulation
<b>MDSW</b>	Medical Device Software
<b>ML</b>	Machine Learning
<b>NB</b>	Notified Bodies
<b>PMS</b>	Post-Market Surveillance
<b>QMS</b>	Quality Management System
<b>RAPS</b>	Regulatory Affairs Professionals Society
<b>TFEU</b>	Treaty on the Functioning of the European Union
<b>UDI</b>	Unique Device Identification

# 1

## Introduction

## Introduction

This dissertation has been developed to obtain the Master of Science Degree in Biomedical Engineering and Biophysics. The research was carried out in collaboration with Compliance Tech, Sociedade Unipessoal Lda. (referred to hereafter as Compear), a company that facilitates regulatory compliance with medical device software for market entry.

In the context of the European Union's Medical Device Regulation, the certification process of medical device software is crucial yet complex. This work aims to study the first step of this certification process thoroughly – the qualification and classification of medical device software.

This chapter opens with an overview of the background of medical devices and the evolution of their regulatory framework. It further outlines the motivation behind the development of this master's thesis, detailing the factors that inspired its conception. Additionally, the chapter highlights the original contributions made through this work. It concludes with a complete outline of the content and structure of the thesis, offering readers a roadmap for what they can expect in the following chapters.

### 1.1. Background

Medical devices have become an essential part of modern healthcare, encompassing a broad range of instruments, apparatuses, implants, and software used for diagnosing, treating, monitoring, and preventing various diseases and medical conditions [1].

The history of medical devices dates back to 6000 BC, when rudimentary medical instruments, such as knives, saws, and drills, were used. These primitive devices performed procedures such as amputations, trepanation, and other basic surgeries. Since then, medical devices have come a long way, and today, we have highly advanced and sophisticated medical equipment. The evolution of medical devices has played a crucial role in the advancement of modern medicine, and it continues to revolutionize the healthcare industry every day [1].

Before the latter part of the 1930s, medical devices were commercialized similarly to any other consumer good [2]. It wasn't until then that the regulation of medical devices gained momentum, particularly in response to public health concerns, such as the risks associated with electrical currents in devices connected to patients and adverse effects from early contraceptive devices [3]. These incidents highlighted the need for stricter oversight, leading to the first regulatory framework to protect patient safety while fostering innovation in medical technology.

Regulation of medical devices is critical to ensuring their safety and effectiveness for their intended use. These regulations establish strict standards for the design, production, and distribution of medical devices, enhancing their quality and reducing the risk of harm to patients. Manufacturers must conduct rigorous testing and clinical trials to demonstrate the performance and safety of their devices, evaluating potential risks and implementing measures to mitigate them. By adhering to these regulatory requirements, manufacturers can provide healthcare providers and patients with high-quality medical devices that meet established safety standards.[4].

In the European Union (EU), the regulatory landscape for medical devices has evolved significantly. The Medical Device Directive (MDD) 93/42/EEC, introduced in 1993, was one of the first comprehensive regulatory frameworks aimed at ensuring the safety and performance of medical devices across Member States [5]. However, with the fast advancement of technology and the increasing complexity of medical devices, the MDD was replaced by the Medical Device Regulation 2017/745 (MDR). This introduced more stringent requirements for the classification, design, and post-market surveillance of medical devices, including software [5].

The qualification and classification of medical devices, particularly Medical Device Software (MDSW), present significant challenges due to technology's complex and evolving nature. Proper

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classification is crucial, as it determines the level of regulatory scrutiny necessary to ensure the safety and effectiveness of these devices. Misclassification can lead to inadequate regulation, posing risks to patient safety. As the industry continues to innovate, new challenges arise, especially with the integration of artificial intelligence (AI) and the growing importance of cybersecurity. In response, the European Union is drafting the AI Act to address the specific risks associated with AI in medical devices. This evolving regulatory landscape underscores the need for ongoing adaptation and vigilance to ensure that medical devices remain safe, effective, and secure in an increasingly digital healthcare environment.

### 1.2. Motivation

Medical devices are an incredible asset to both patients and healthcare professionals. They range from simple tools like tongue depressors to advanced software capable of extracting insights from radiology images that exceed human capabilities. However, bringing these innovative ideas to market requires navigating a complex and often challenging regulatory pathway.

During the "Medical Device II" course, I realized the importance of understanding how a medical device is deemed safe. In a world where new technologies constantly emerge, there should be a heightened level of critical thinking and awareness about the safety and efficacy of products that claim to solve significant health issues. This realization sparked my interest in delving deeper into the regulatory processes that medical devices undergo to ensure they meet the required safety standards.

My internship with Complear further solidified this interest by presenting me with the challenge of working with MDSW. Unlike traditional hardware medical devices, MDSW is notoriously difficult to qualify and classify due to the lack of clear guidelines. The ambiguity in classification presents a significant barrier to innovation, as it complicates bringing new software to the market. However, this challenge also provided me with a unique opportunity to deepen my understanding of MDSW and the difficulties involved in its classification.

The motivation behind this research is to contribute to developing a complete and systematic approach to the qualification and classification of MDSW. In an era where MDSWs are becoming increasingly integral to healthcare, it is essential to develop strategies that ensure these innovations can reach the market safely and efficiently. Without a clear regulatory strategy, even the most groundbreaking ideas may never come to a realization. This research aims to bridge that gap, providing valuable insights that will benefit both the medical device industry and the healthcare professionals who rely on these tools to deliver accurate diagnoses and effective treatments to their patients.

### 1.3. Original contributions

The work presented in this thesis has led to the development of two scholarly articles, both of which will be submitted for publication. The first article, *Navigating Regulatory Challenges: Proposed Regulatory Strategy Framework for MDSW*, offers a detailed framework designed to guide medical device software manufacturers in the qualification and classification of their products. This framework addresses existing gaps in the regulatory strategy process, demonstrated through its application to multiple case studies, thereby offering clarity and structure to a complex regulatory landscape.

The second article, *Compliance of MDSW in Portuguese Hospitals*, builds upon the framework introduced in the first article by applying it to software currently used in Portuguese public hospitals.

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This study assesses the compliance of these software systems with the EU MDR, providing valuable insights into the regulatory status of medical device software in a real-world healthcare setting.

Additionally, I was privileged to attend the Regulatory Affairs Professionals Society (RAPS) EuroConvergence event in Berlin. During this event, I engaged with experienced professionals in the field of regulatory affairs, gaining a deeper understanding of the daily challenges they face and the potential solutions they have identified. The feedback and insights gathered from these interactions have been incorporated into this dissertation, further enriching its practical relevance and grounding it in current industry perspectives.

### 1.4. Thesis outline

This thesis is structured to provide a complete exploration of the development and application of regulatory strategies for MDSW.

The second chapter – Case Studies – begins with a detailed description of Complear, including its services and digital platform, to contextualize the practical environment of the research. This is followed by an introduction to the concept of MDSW, highlighting its significance in the healthcare industry. The chapter concludes by examining the specific case studies encountered during the internship and identifying the challenges in developing an effective regulatory strategy.

The third chapter - Literature Review – presents a literature review that delves into the European medical device regulation landscape, focusing on the certification process for MDSW. This review critically examines the existing regulatory framework, emphasizing the importance of a well-defined regulatory strategy. The literature review provides the foundation for understanding the development and rationale behind the subsequent chapters.

In Chapter 4 - Navigating Regulatory Challenges –, the focus shifts to the regulatory strategy framework developed to address the challenges identified in the case studies. This chapter thoroughly explains the framework's structure and methodology, followed by its practical application using a hypothetical product to illustrate its effectiveness.

Chapter 5 - Compliance of MDSW in Portuguese Hospitals outlines the methodology employed in the compliance assessment, emphasizing its significance. It presents the results and discusses the findings, shedding light on the current state of MDSW regulation in Portugal.

The thesis concludes with Chapter 6 – Final Remarks –, where I reflect on the work conducted during the internship and discuss its significance, challenges, and limitations. This final chapter encapsulates the insights gained throughout the research and underscores the broader implications of the developed regulatory strategy framework for both regulatory affairs professionals and the healthcare industry.

# 2

## Case Studies

## 2.1. Complear

Complear started its activities in 2021 as a specialized consultancy company dedicated to facilitating the regulatory compliance of medical devices, with a particular focus on MDSW. The company leverages a global network of experts to support its clients' diverse technological needs, offering a broad suite of services to ensure medical devices' safety, efficacy, and market readiness.

Although Complear still offers consultancy services to its clients, in the last two years, it has been developing a platform for a more efficient regulatory framework for its clients.

### 2.1.1. Services

As a consultancy company, Complear offers the following services:

- **Regulatory Strategy and Support.** Complear provides strategic regulatory guidance to help companies navigate the complex landscape of medical device compliance. By identifying potential regulatory challenges early in the development process, Complear enables its clients to take proactive measures, reducing the risk of costly delays and non-compliance issues in the future.
- **Quality Management System (QMS).** Quality is at the core of medical device development, and Complear offers specialized services in implementing and maintaining QMSs, particularly in alignment with ISO 13485:2016 + A11:2021 standards – for simplification reasons these standards will be shortened to ISO 13485. The company also provides internal audit services, ensuring the quality systems are robust, effective, and compliant with regulatory requirements.
- **Medical Device Engineering.** Complear supports the development and maintenance of medical devices through its expertise in medical device engineering. This service ensures that the devices are designed and produced according to the best engineering practices, focusing on safety, reliability, and compliance.
- **Regulatory Documents and Submission Support.** Complear assists clients in creating and maintaining accurate, compliant documentation for their medical devices. The company offers regulatory submission services, which streamline the process of obtaining necessary approvals. This includes conducting gap assessments to identify and address any deficiencies in existing documentation, ensuring a smooth regulatory submission process.
- **Testing and Development Expert Services (Network-Based).** Through its global network, Complear provides access to specialized testing and expert services, which are critical for verifying the safety and effectiveness of healthcare products. These services are designed to ensure that products meet all regulatory and safety standards before they reach the market.
- **Training Academy.** Recognizing the importance of ongoing education, Complear offers a Training Academy focused on the regulatory requirements of medical software, quality management systems, and cybersecurity and information security compliance. These training programs are tailored to equip professionals with the knowledge and skills to navigate the complex regulatory landscape effectively.
- **Cybersecurity and Information Security Compliance.** Recognizing the increasing importance of cybersecurity in the digital age, Complear offers support that combines cybersecurity expertise with compliance frameworks such as the General Data Protection Regulation (GDPR) and ISO 27001. This service is essential for ensuring that medical devices and their associated data systems are secure from cyber threats, protecting patient data, and maintaining compliance with stringent information security standards.

### 2.1.2. Compear's Digital Platform

In addition to its consultancy services, Compear is at the forefront of innovation with the development of a digital platform. This platform is designed to streamline the journey of bringing medical device software to market, integrating crucial aspects such as planning, regulatory compliance, and quality management from the beginning of the development process. By leveraging technology and a user-centric approach, Compear's platform aims to simplify and enhance the efficiency of the regulatory pathway for medical device software, ensuring that teams can focus on innovation while maintaining stringent compliance with industry standards.

Some prominent features that Compear's Digital Platform offers or will offer are:

- **Product Strategy and Definition.** One of the core features of Compear's platform is its support for product strategy and definition. This module guides teams in strategically planning new products or features, including critical aspects such as Design & Development and Risk Management. Notably, the platform offers specialized tools for AI Development and Validation, addressing the growing integration of artificial intelligence in medical device software. This feature ensures that new products are not only innovative but also rigorously developed and validated to meet the highest standards of safety and effectiveness.
- **Electronic Technical Documentation (Future Module).** Compear is pioneering the automation of technical documentation with its forthcoming Electronic Technical Documentation (eTD) module. Powered by AI Compear GPT, this module will automate the creation and management of eTD, significantly reducing the time and effort required to compile and maintain these essential regulatory documents. By utilizing AI, the eTD module promises to enhance accuracy and consistency, ensuring that all documentation complies with regulatory requirements while freeing up valuable resources for other critical tasks.
- **Electronic Quality Management System (Future Module).** Another future enhancement to Compear's platform is the Electronic Quality Management System (eQMS) module. This feature is designed to digitize and streamline quality management processes, making it easier for teams to implement and maintain robust QMS practices in compliance with standards such as ISO 13485. The eQMS module will provide real-time insights and control over quality processes, ensuring that all aspects of product development meet the required quality benchmarks from conception to market release.
- **Training Academy.** Complementing the platform's technical features, Compear's digital Training Academy offers targeted education and training on critical topics such as regulatory requirements for medical software, quality management systems, and cybersecurity and information security compliance. This feature ensures that platform users are equipped with the tools they need and the knowledge to use them effectively in the highly regulated field of medical device software development.

## 2.2. Medical Device Software (MDSW)

Medical Device Software refers to software specifically intended for medical purposes, either as a standalone product or as part of a medical device. Unlike general-purpose software, MDSW is designed according to Article 2 of MDR, for one or more of the following specific medical purposes:

- Diagnosis, prevention, monitoring, prediction, prognosis, treatment, or alleviation of a disease;
- Diagnosis, monitoring, treatment, alleviation of, or compensation for, an injury or disability;

- Investigation, replacement, or modification of the anatomy or of a physiological process or state;
- Providing information by means of *in vitro* examination of specimens derived from the human body, including organs, 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. [6].

Although most MDSW fall under the regulatory framework of MDR, it is essential to recognize that some may also be subject to the *In Vitro* Diagnostic Medical Device Regulation (IVDR). The IVDR provides a distinct definition of MDSW, stating that these may be used alone or in combination, and are intended by the manufacturer for use *in vitro* for the examination of specimens – such as blood and tissue donations – derived from the human body, primarily for the purpose of providing information in one or more of the following areas:

- Concerning a physiological or pathological process or state;
- Concerning a congenital physical or mental impairments;
- Concerning the predisposition to a medical condition or disease;
- Determining safety and compatibility with potential recipients;
- Defining or monitoring therapeutic measures.

Moreover, specimen receptacles are also classified as *in vitro* diagnostic medical devices under this regulation [7].

Following the definitions provided by the MDR and IVDR, MDSW encompasses a wide range of software applications with diverse functionalities and purposes. MDSW can be categorized into several distinct types based on their intended use, as illustrated in Figure 2.1 [8].

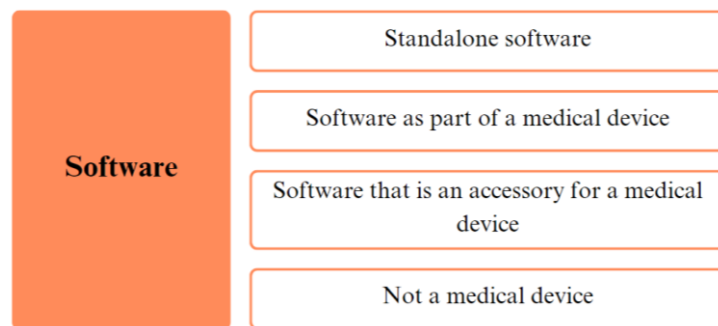


Figure 2.1. Categories of software as a medical device.

Standalone Software is growing quickly and refers to software used independently as a medical device. Examples include digital health applications, such as Digital Health Apps, commonly used for self-diagnosis or self-treatment [9].

Embedded Software is software integrated into a physical medical device to control its functions. For instance, software embedded in a pacemaker to regulate heart rhythms or in an MRI to process and display images [9]. This kind of software is widely used, but the trend is shifting towards standalone rather than embedded software.

Software that is an accessory for a medical device is intended to be used together with one or more medical devices to enable them to fulfill their intended purpose [10]. An example could be software that interfaces with a medical device to transfer data to electronic health records.

### 2.2.1. Market Growth and Importance

The MDSW market is growing rapidly due to advancements in digital technology, increased adoption of connected health solutions, and the rising demand for personalized and remote healthcare. Integrating software into medical devices has transformed the healthcare landscape, enabling more accurate diagnostics, better patient monitoring, and enhanced therapeutic interventions [11].

The global MDSW market has been expanding significantly, with projections indicating continued robust growth in the coming years. According to industry reports, the MDSW market is valued at approximately USD 1.8 billion in 2024 and is expected to reach around USD 6.1 billion by 2034, growing at a compound annual growth rate of over 13% [11]. This growth is fueled by several factors, including:

- **Technological Advancements.** Ongoing innovation in AI, machine learning (ML), and big data analytics has enabled the development of more sophisticated and powerful MDSW. These technologies allow for improved diagnostic capabilities, predictive analytics, and personalized treatment plans, making MDSW indispensable in modern healthcare [12].
- **Increasing Prevalence of Chronic Diseases.** The rising incidence of chronic conditions such as diabetes, cardiovascular diseases, and cancer has led to a greater demand for MDSW that can assist in managing these conditions. Software applications that support continuous monitoring, remote patient management, and telemedicine are becoming essential tools in chronic disease management [13].
- **Regulatory Support and Initiatives.** Governments and regulatory bodies worldwide recognize the importance of MDSW in healthcare delivery and are establishing frameworks to ensure its safe and effective use.
- **Shift Towards Home Healthcare.** The COVID-19 pandemic has accelerated the adoption of telemedicine and remote healthcare solutions, with MDSW playing a crucial role in enabling these services. Patients are increasingly using MDSW for self-monitoring and managing their health from home, reducing the need for in-person consultations and hospital visits [14].

The growth of the MDSW market is not just a reflection of technological advancements but also an indication of its increasing importance in the healthcare industry. MDSW has become indispensable for accurate diagnostics, personalized treatments, and efficient patient management [9]. However, the software's complexity introduces new challenges and risks. Software errors, cybersecurity vulnerabilities, and interoperability issues can lead to severe consequences, including incorrect diagnoses, treatment delays, and compromised patient safety. While these devices have numerous benefits, it is also essential to acknowledge the potential risks they pose to users. It is crucial to exercise caution and take necessary safety measures to prevent any harm.

This fast expansion brings both significant challenges and opportunities. One primary challenge is regulatory compliance. The changing regulatory landscape, particularly with the introduction of the MDR and the upcoming AI Act, means that companies must stay updated on new regulations and ensure their software meets all requirements. The complexity of these regulations can be overwhelming for smaller companies and startups. Elizabeth Gfoeller stated during the opening ceremony of RAPS Euro Convergence 2024 in Berlin that most companies developing medical device software are smaller enterprises that most likely lack the resources of larger corporations.

Cybersecurity is another critical challenge, as the increasing digitalization of healthcare makes MDSWs more vulnerable to cyberattacks. Ensuring the security of patient data and protecting software

from malicious threats is paramount. This requires robust security measures and continuous monitoring to identify and mitigate potential vulnerabilities [15].

On the other hand, the MDSW market offers significant opportunities, particularly in AI and personalized medicine. Companies that can effectively integrate AI into their software solutions have the potential to revolutionize healthcare by providing more accurate diagnostics and tailored treatments [12]. The demand for remote healthcare solutions is also expected to continue growing, offering companies opportunities to develop innovative telemedicine and remote monitoring software.

Moreover, the global push towards digital health transformation provides fertile ground for the expansion of MDSWs. As healthcare systems worldwide seek to improve efficiency and patient outcomes through digital technologies, there is a growing demand for software solutions that can enhance clinical workflows, improve patient engagement, and facilitate data-driven decision-making [9].

### 2.3. Product Assessments

During my internship at Compear, I played a crucial role in assisting companies with the initial phase of navigating the regulatory framework, a process known as regulatory strategy development. This phase typically started with an initial meeting, where I engaged closely with the client's team to gain an in-depth understanding of their product. The primary objective of these meetings was to uncover the product's functionalities, intended use, and operational processes, which were essential for producing a tailored regulatory strategy.

Once all relevant information was gathered, I began developing a regulatory strategy report. This report outlined the product features, their qualification and classification according to the MDR, and possible classification scenarios regarding the features listed. It also includes the necessary steps to achieve regulatory compliance and market readiness.

I had the opportunity to contact six different companies and learn more about their products while helping them establish the best regulatory strategy. The next subchapters will briefly describe each company's product, keeping the privileged information anonymous. The information utilized next can be found on their websites; no privacy policies were corrupted when writing about each company.

#### 2.3.1. Case Study 1: Portable Breast Cancer Health Monitoring Device

A portable device was developed to complement breast cancer self-examinations. It was designed to be connected to a mobile application for enhanced detection and monitoring of changes in breast tissue. This device offers several key features, including reminders for users to perform regular home screening exams and guidance on conducting self-examinations. This functionality facilitates the collection of thorough, self-generated data, which users can easily present to their healthcare providers.

The device is user-friendly, requires no specialized knowledge to operate, and is accessible to a wide range of users. Additionally, it provides a detailed follow-up system that tracks the user's breast health over time, allowing continuous monitoring from the comfort of their home. This feature empowers women to manage their breast health proactively, contributing to earlier detection and more informed discussions with their doctors.

### 2.3.2. Case Study 2: Facial Rehabilitation App

A mobile app was created for people with facial paralysis and temporomandibular joint disorders. It provides a structured set of facial exercises designed by expert therapists and specialized doctors. The app is equipped with features allowing users to monitor their condition's progression and offers a platform for scheduling virtual consultations with healthcare professionals.

This application aims to complement traditional therapeutic strategies by enabling users to manage their exercises independently while maintaining convenient access to their doctors. It is important to note that the app is not intended to replace professional medical advice or in-person therapy sessions; rather, it serves as a supplementary tool designed to enhance therapeutic outcomes through consistent practice and detailed progress tracking.

### 2.3.3. Case Study 3: Endometriosis Detection Software

This software is designed to enhance transvaginal ultrasound scanning for the noninvasive detection of endometriosis in women of childbearing age. It uses artificial intelligence and classical algorithms to analyze transvaginal ultrasound video data to identify signs of endometriosis. Its primary objective is to reduce reliance on invasive laparoscopy procedures, offering a safer and more efficient diagnostic alternative.

### 2.3.4. Case Study 4: Ear Infection Detection Device

This non-invasive device is designed to measure and analyze the color of the middle ear and ear canal, enabling the early detection of ear infections. The device allows families to diagnose the presence or absence of infection at home, eliminating the need for a physician or healthcare specialist for the initial assessment. This offers a convenient and accessible solution for early ear infection detection.

### 2.3.5. Case Study 5: Colorectal Cancer Digital Health Platform

This digital health platform is specifically designed for patients suffering from colorectal cancer. The platform provides personalized healthcare by integrating medical record analysis, scientific evidence tailored to genetic mutations, therapies' potential side effects, and additional medical consultation resources. It includes a curated list of doctors who can provide second opinions. The platform aims to empower colorectal cancer patients by enhancing their understanding of their disease, enabling them to make informed decisions about their treatment.

### 2.3.6. Case Study 6: Integrated Clinical Trial Management and Remote Patient Monitoring System

This solution combines a clinical trial management system with a remote patient monitoring platform. The system is designed to trigger warnings and emergency events during clinical trials when vital signs fall outside the established parameters or when adverse events occur. It also monitors the effectiveness of treatments. The platform facilitates the remote monitoring of patient's vital signs and medical history, supporting diagnosis, follow-up, and treatment throughout the clinical trial process.

## 2.4. Identifying the implementation problem of regulatory strategy

The qualification and classification of MDSW are critical yet complex processes under the MDR. These processes are governed by various rules and guidelines, including the Medical Device Coordination Group (MDCG) guidelines, such as the MDCG 2019-11, which provides specific guidance on the regulation's rules for software-based medical devices. However, applying these rules can be challenging due to the intricacies involved in understanding the software's intended purpose, functionality, and impact on patient safety.

Creating a thorough and clear regulatory structure that provides transparency and definitiveness is crucial to minimize errors and misinterpretations.

# 3

## Literature Review

This literature review seeks to enhance knowledge of the essential prerequisites for manufacturers to adhere to the Medical Device Regulation and formulate optimal product strategies. The review will start with a brief introduction to the importance of regulating MDSW. It will also discuss the regulatory entities responsible for ensuring that MDSW entering or already in the market comply with the applicable regulations. Furthermore, the review will explore the regulations applied in the European Union – the EU MDR – and the differences between these newer regulations and the previously implemented – Medical Device Directive. Finally, the review will cover the regulatory pathway that MDSW must follow to obtain the CE marking, focusing mainly on available regulatory strategies. Simultaneously, a gap analysis will be conducted on this topic to explore new ways of doing things and cover them.

### 3.1. Importance of MDSW Regulation

Software is often not considered a medical device by most people, as they are more familiar with physical medical devices, which are hardware. This misconception is not limited to ordinary individuals, as even software developers or top management from such companies may not always realize that the software they are creating qualifies as a medical device. However, with the accessibility of information online and technological advancements, most software developers and top management of such companies are now aware of whether their product qualifies as a medical device. Only recently has more attention been given to medical device software.

Regulating MDSW is crucial for ensuring patient safety, as software now plays a pivotal role in diagnostics, treatment planning, and patient monitoring. Malfunctions or errors in medical software can lead to incorrect diagnoses or inappropriate treatment recommendations, which can have severe or even life-threatening consequences. Regulatory frameworks ensure that MDSW meets stringent quality standards, is thoroughly tested, and is reliable for critical healthcare scenarios. Additionally, given that MDSW often handles sensitive patient data, regulations ensure it is securely managed, protecting it from unauthorized access and breaches.

Furthermore, while regulation imposes necessary constraints, it also supports innovation by providing developers with a clear compliance framework, helping them navigate the complexities of bringing new and innovative software solutions to market. As MDSW continues to evolve and become integral to healthcare, robust regulation remains essential to balance innovation with patient safety and data security.

#### 3.1.1. Regulatory Entities

Regulatory bodies such as the Food and Drug Administration (FDA) in the United States and the European Commission, the National Competent Authorities and in some cases European Medicines Agency (EMA) in the European Union oversee and regulate medical devices. These organizations are responsible for setting and enforcing standards to ensure that medical devices are safe and effective. The FDA in the US and Notified Bodies in the EU review and approve devices before they can be marketed, monitor adverse events, and conduct inspections of manufacturing facilities. Doing so, they help to protect public health and maintain trust in medical technologies [16] [17].

In Europe, each member state has a competent authority overseeing and regulating medical device production, distribution, commercialization, and use to ensure compliance with EU legislation. In Portugal, this authority is INFARMED - Autoridade Nacional do Medicamento e Produtos de Saúde,

which is tasked with ensuring that medical devices are safe, effective, and meet the necessary standards for use in the country [18].

In certifying medical devices, other regulatory entities, known as Notified Bodies (NB), play a crucial role. Each EU member state designates these authorities to conduct conformity assessments in line with the MDR [19]. Their task is to ensure that medical devices meet the necessary standards before they are introduced into the market, which includes granting CE marking. It is the responsibility of the EU to keep an updated record of NBs in EU countries – the updated list can be consulted in [20]. Engaging with NBs can be time-consuming due to the long waiting times for certification requests at these institutions. This problem has been intensified by a recent significant decrease in the number of NBs. Many of them failed to meet the requirements of the MDR 2017/745 and did not make the transition from the MDD. Additionally, this process involves significant financial expenses, that typically companies are not aware of. Portugal's lack of its own NB for medical devices makes it even more difficult for local manufacturers who must find alternative European NBs to carry out necessary conformity assessments. This comes with an extra financial cost, as typically travel is not included in pricing, as well as language barriers and potential consequential costs for translations.

### 3.1.2. Harmonization of Global Regulations

Efforts are also being made to harmonize medical device regulations globally. Organizations such as the International Medical Device Regulators Forum (IMDRF) work towards aligning regulatory requirements across different jurisdictions [21].

Harmonization initiatives include developing common standards and guidelines, mutual recognition agreements, and collaborative regulatory initiatives. For instance, the IMDRF's work has led to the creation of internationally recognized guidelines on various aspects of medical device regulation, including clinical evaluation, risk management, and post-market surveillance [21].

The benefits of harmonization are significant. It streamlines the regulatory process for manufacturers, reducing the time and costs associated with bringing medical devices to multiple markets. For regulatory bodies, it fosters greater cooperation and information sharing, leading to more consistent enforcement of safety standards [21].

While harmonization presents challenges, such as reconciling differing regulatory frameworks and legal systems, international organizations' ongoing efforts continue progressing towards more unified global standards. These efforts are crucial in an increasingly interconnected world where medical devices are developed, manufactured, and used across borders.

Transitioning from the broader context of global regulatory harmonization, it is essential to delve deeper into the specifics of the European Union's regulatory framework, which plays a pivotal role in the global landscape.

## 3.2. The European Medical Device Regulation (MDR)

Legislation concerning medical device regulation was introduced in Europe quite late compared to the United States of America, with the goal of creating an internal European market. . As seen in Figure 3.1, it was in the early 1990s that the European Union began to introduce a regulatory environment due to safety concerns with various medical devices [22], with the Directive 93/42/EEC on Medical Device Directive, Directive 98/79/EC on *In Vitro* Diagnostic Medical Devices (IVDD) and Council Directive 90/385/EEC on implantables. In the subsequent years, incidents of harm caused by medical devices, such as the Poly Implant Prothèse silicone breast prostheses scandal [23] and the metal-

on-metal hip prosthesis [24], came to light. In response, the European Commission accelerated the development of new regulations after realizing that the current device regulatory processes were outdated. The initiative's main objective is to enhance the safety of medical devices available in the European market and strengthen the credibility and reputation of the regulatory system. These efforts resulted in the publication of the new MDR in 2017 [25].

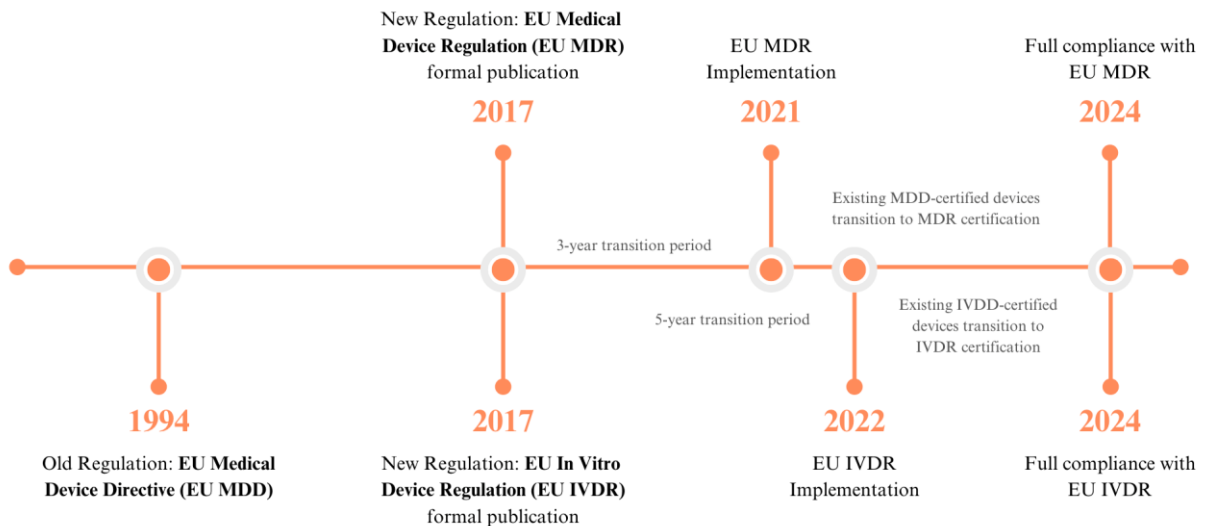


Figure 3.1. Evolution throughout the years of medical device regulations in the EU.

After the publication of MDR, a 3-year transition period allowed manufacturers to evaluate their devices under either MDD or MDR. However, starting May 2021, all medical devices must be approved according to MDR processes. The certificates for devices already on the market, known as legacy devices, were extended and remained valid for an additional four years, up to May 2024 [25].

Alongside the creation of the MDR, the IVDD was similarly replaced by IVDR. This transition aimed to enhance the regulatory framework governing *in vitro* diagnostic devices, introducing more stringent safety, performance, and transparency requirements, much like the shift from the MDD to the MDR.

The EU MDR and IVDR ensure the proper functioning of the internal market for medical devices while prioritizing the protection of patients' and users' health. The regulations also consider small- and medium-sized enterprises operating in this sector. It sets high standards for the quality and safety of medical devices to address common safety concerns. Both objectives are equally important and closely connected. Following Article 114 of the Treaty on the Functioning of the European Union (TFEU), this regulation standardizes the rules for placing and using medical devices and their accessories in the Union market. This allows them to benefit from the principle of free movement of goods. Article 168(4)(c) of TFEU [26] aims to establish stringent quality and safety standards for medical devices. This regulation ensures the reliability and robustness of data generated during clinical investigations and protects the safety of individuals participating in such investigations [19].

### 3.2.1. Differences between MDD and MDR

The shift from the MDD to the MDR entails considerable effort for manufacturers, though much of the MDR builds upon existing regulations to converge with global standards. Despite the MDD's age, continuous updates to European standards and guidance ensure that manufacturers already complying

with current requirements will face minimal new challenges with the MDR [27]. It's important to note that the differences observed in the transition from the IVDD to the IVDR mirror those outlined in the shift from the MDD to the MDR. Figure 3.2 lists the main differences and similarities between the MDR and the MDD.

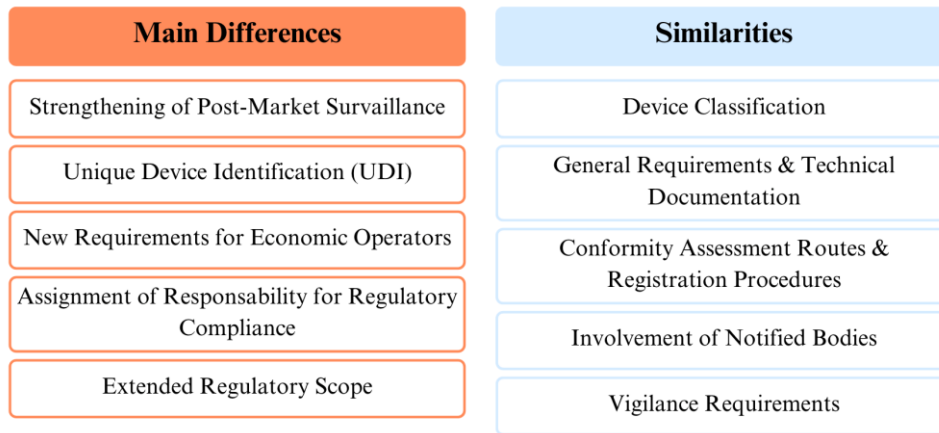


Figure 3.2. Differences and Similarities between MDR and MDD

The revised MDR retains several aspects from the MDD, including device classification, general requirements, technical documentation, conformity assessment routes, registration procedures, involvement of Notified Bodies, the EUDAMED database, and vigilance requirements [27].

The MDR has introduced new requirements designed to improve the safety and performance of medical devices in Europe. One of the most significant changes is strengthening post-market surveillance (PMS), which will now include increased oversight by Notified Bodies. This ensures that any medical device issues are identified and addressed quickly. In addition, the MDR has mandated the introduction of PMS Reports or Periodic Safety Update Reports [27]. These reports will provide regulators with more detailed information about the safety and performance of medical devices, enabling them to take swift action if necessary.

Another critical requirement of the MDR is the implementation of Unique Device Identification (UDI). This practice has already been established in the United States and will now be mandatory in Europe. UDI will enable regulators to track medical devices more effectively, making it easier to identify any issues that may arise [27].

The MDR includes new requirements for economic operators, such as importers and distributors. These requirements align European practices with global standards, ensuring that medical devices are imported and distributed safely and securely [27]. By implementing these requirements, the MDR aims to improve the safety and performance of medical devices across Europe, ultimately benefiting healthcare providers and patients alike.

Finally, another change is the formal assignment of responsibility for regulatory compliance within organizations, which ensures accountability and transparency. Furthermore, the regulatory scope has been extended to include previously exempted products – such as colored non-corrective contact lenses – thereby increasing the safety and efficacy of medical devices [27]. These changes represent a significant step towards ensuring the highest patient safety and regulatory compliance standards.

### 3.3. Medical Device Software Certification Process

The certification process for medical devices (MD) or *in vitro* medical devices is a critical pathway that manufacturers must navigate to demonstrate compliance with regulatory requirements and to ensure that their products are safe and effective for public use. This process varies by region, with distinct procedures in places such as the United States, European Union, and other markets. In Figure 3.3 are the general steps involved in the certification process for medical devices in the European Union under the MDR.

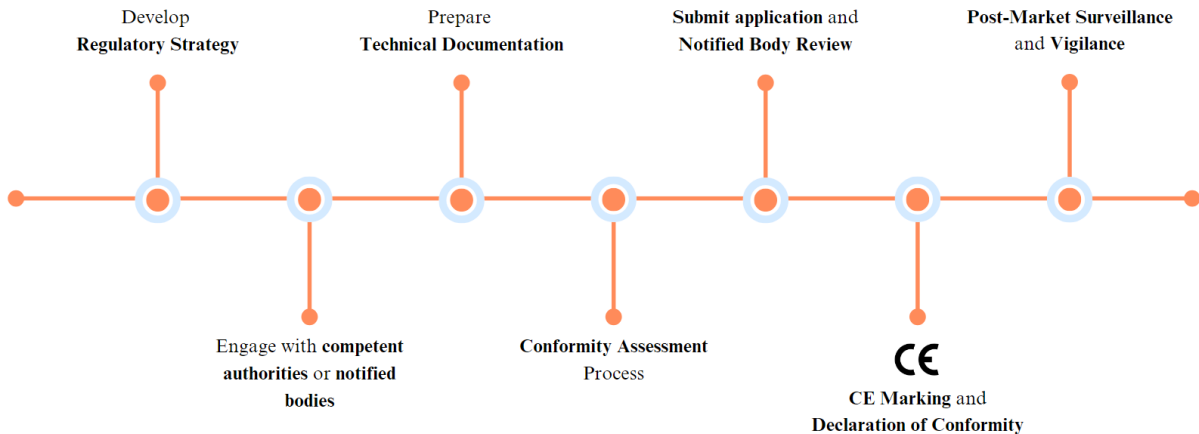


Figure 3.3. Simplified Medical Device Software Certification Process in the EU.

#### 3.3.1. Regulatory Strategy

The first step that every manufacturer must take is to develop a regulatory strategy for their software. This is a critical step that sets the foundation for ensuring compliance with regulations throughout the product's lifecycle - the length of time that a product is available to customers [28]. The strategy involves several key components and considerations. The first step is to thoroughly understand the applicable regulation, such as MDR or IVDR, and how it applies to the software being developed. This involves familiarizing oneself with the requirements set out in the MDR and/or IVDR, including classification rules, conformity assessment procedures, and post-market obligations.

##### 3.3.1.1. *Product Qualification*

Software must have a medical purpose on its own to be considered a medical device, but other criteria also need to be considered. The European Commission has created a questionnaire to assist manufacturers and others in determining whether their software meets the definition of a medical device. Figure 3.4 is an adapted version of the European Commission's questionnaire.

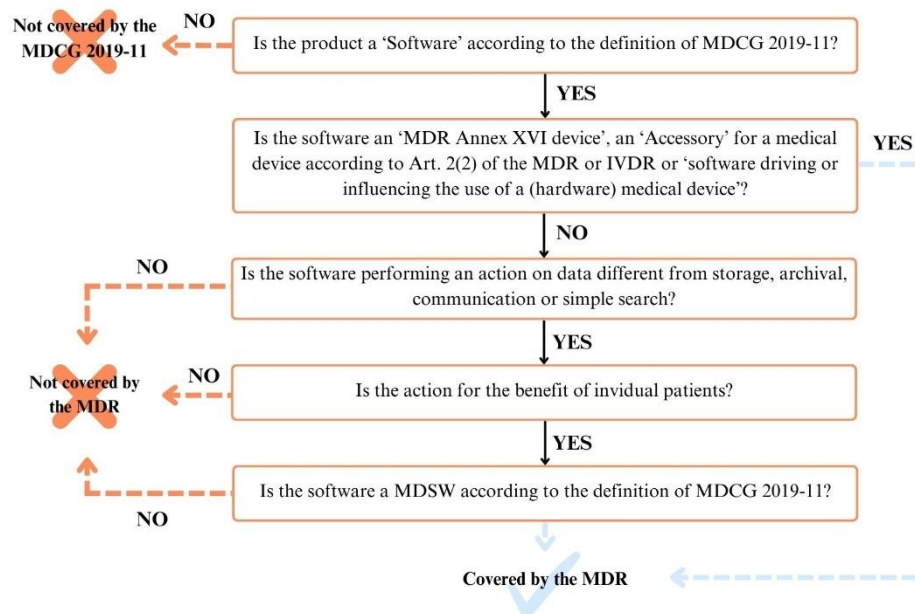


Figure 3.4. Decision steps to assist qualification of a Medical Device Software based on MDCG 2019-11 [29].

Understanding the definitions of a medical device and medical device software is necessary. It helps to navigate the regulatory landscape effectively. Article 2 of the MDR defines a medical device:

*'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 [6].*

The definition of medical device software is provided in MDCG 2019-11 – a document that guides medical software manufacturers on the qualification and classification of their products. The definition declares that:

*Medical device software is software that is intended to be used, alone or in combination, for a purpose as specified in the definition of a "medical device" in the medical devices regulation or in vitro diagnostic medical devices regulation [7].*

Despite the regulatory definitions for medical devices and MDSW, manufacturers often grapple with significant challenges in determining whether their software qualifies as a medical device. The primary hurdle is the ambiguity in definitions, especially when software has both medical and non-medical functionalities. This is further complicated by the rapid pace of technological advancement, particularly in areas like artificial intelligence, which can surpass the existing regulatory frameworks,

leaving gaps in qualification criteria. Additionally, the guidance provided by regulatory bodies may not be sufficiently detailed to cover all scenarios, particularly for novel or complex software, leading to inconsistent interpretation and application by manufacturers.

The uncertainties in qualifying MDSW can lead to several significant consequences. First, regulatory uncertainty can cause delays in market access, as manufacturers may hesitate or face setbacks if the qualification status of their software is unclear. This can also increase compliance costs, especially if a product is misclassified initially, necessitating costly redesigns to meet regulatory standards. More critically, the inconsistent application of qualification criteria across different products can undermine patient safety, as software that should be regulated might bypass essential safety and performance evaluations. Addressing these issues through enhanced guidance, industry collaboration, and global regulatory harmonization is crucial to ensure patients' safety and the efficiency of bringing innovative medical software to market.

### 3.3.1.2. *Classification of Medical Device Software*

If, after answering all the questions in the questionnaire, the answer indicates that the MDR covers the software, the next step is to determine the class of the medical device software.

The MDR classifies medical devices into Risk Classes in Annex VIII (which are also covered and more guidance and examples are provided in MDCG 2021-24 – a document for guidance on the classification of medical devices).

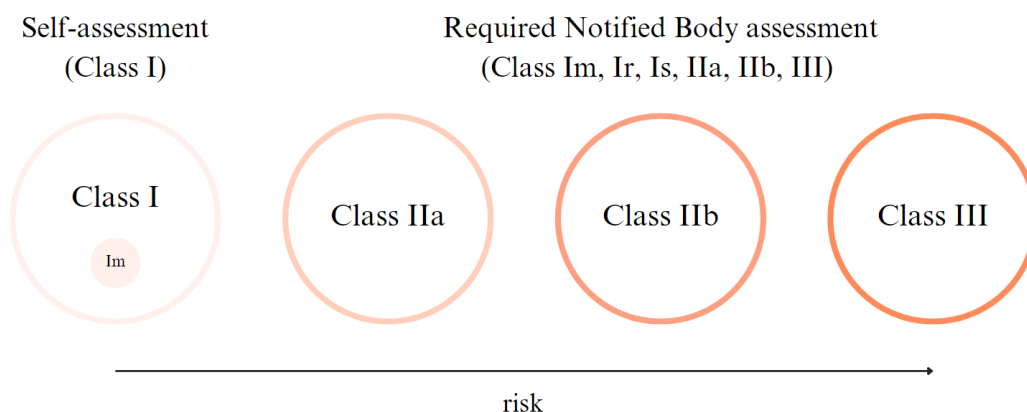


Figure 3.5. Risk Classification according to MDR.

This classification system is based on the risk that the MDSW may pose, with higher risk corresponding to a higher class. The classes, as illustrated in Figure 3.5, are:

- **Class I:** Low-risk, non-invasive, everyday devices or appliances are classified as class I devices. The manufacturer is required to complete technical files for such devices [30].
  - **Class Im** (with measuring function): Similar low-risk measuring devices. The manufacturer must provide a technical file and be certified by a European Notified Body for conformity assessment of this special function [30].
  - **Class Ir and Class Is:** address characteristics related to the physical nature of medical devices, such as reusability (Class Ir) and sterility (Class Is). These subclasses apply to devices where reprocessing or maintaining a sterile state is critical to their safe use. These cases do not apply to MDSW since they don't have a hardware component.
- **Class IIa:** medical devices that generally pose low to medium risk and are primarily implanted in the body for short periods. The requirements for these devices include technical files and conformity assessment conducted by a European Notified Body [30].

- **Class IIb:** devices that are slightly more complex than class IIa devices and are generally considered to be of medium to high risk. The requirements for these devices include technical files and conformity assessment conducted by a European Notified Body [30].
- **Class III:** Devices are considered high-risk and require the technical files and conformity assessment conducted by a European Notified Body [30].

An essential addition to the MDR is Rule 11. This rule was introduced to evaluate the unique considerations related to the introduction of medical device software and establish a clearer process for determining the classification of such software within the regulatory framework. Rule 11 states:

*Software intended to provide information which is used to take decisions with diagnosis or therapeutic purposes is classified as class IIa, except if such decisions have an impact that may cause:*

- *death or an irreversible deterioration of a person's state of health, in which case it is in class III; or*
- *a serious deterioration of a person's state of health or a surgical intervention, in which case it is classified as class IIb.*

*Software intended to monitor physiological processes is classified as class IIa, except if it is intended for monitoring of vital physiological parameters, where the nature of variations of those parameters is such that it could result in immediate danger to the patient, in which case it is classified as class IIb.*

*All other software is classified as class I [7].*

Despite the MDR creating this rule to simplify the process, Rule 11 has faced criticism for its lack of clarity, especially regarding the fact that the classification does not always reflect the level of risk [31]. Since risks are a combination of degrees of severity and probabilities, Rule 11 does not consider this aspect.

This ambiguity may lead to inconsistent classification decisions, potentially causing excessive or insufficient regulation of certain software products. The consequences of these limitations are significant. For instance, the uncertainty surrounding classification could delay the time-to-market for critical software as manufacturers seek clarification or choose a more conservative classification to avoid regulatory risks. On the other hand, under-classification of certain software could expose patients to unrecognized risks, undermining the effectiveness of the regulatory framework.

### **3.3.1.3. Conformity Assessment Pathway**

Upon gathering all the necessary information regarding product qualification and classification, it is essential to choose a suitable route for assessment. Depending on the classification, the manufacturer must select the appropriate conformity assessment route. This could involve self-certification for Class I devices or collaboration with a Notified Body for higher-risk devices. The strategy should outline the specific route and the steps required for each class.

When dealing with higher-risk devices, it's important to select a Notified Body early on. The Notified Body will assess the Technical Documentation and conduct audits to confirm compliance with the MDR. The strategy should outline the criteria for choosing a Notified Body, including their expertise in software and the relevant medical field.

An exception is made when discussing in-house medical devices, which are manufactured and used within healthcare institutions to meet specific patient needs unmet by CE-marked devices. Under Article 5(5) of the MDR, these devices are exempt from conformity assessments but must still comply

with Annex I safety and performance requirements, with documentation available for competent authorities.

### 3.3.2. Technical Documentation

Manufacturers must create and maintain technical documentation to demonstrate that their medical devices meet regulatory requirements. This documentation proves that the device meets essential requirements and has undergone proper assessment and evaluation processes. It covers a wide range of information related to the device's design, manufacture, performance, and safety throughout its lifecycle [32].

The technical documentation should be systematically organized and readily available for review by competent authorities, notified bodies, and other stakeholders involved in regulatory oversight. It typically includes the following components:

- **Device Description and Specification**

The technical documentation for a medical device must include a detailed description and specification of the device. This covers several aspects, including the product or trade name, intended purpose, and intended users. It should clearly state the Basic Unique Device Identifier (UDI-DI) or provide a clear identification for traceability purposes. Additionally, it should outline the patient population for which the device is intended, along with any medical conditions to be diagnosed, treated, or monitored. The documentation should describe the device's operating principles and mode of action, scientifically demonstrated if necessary. It should justify the device's classification and any novel features it may possess. Furthermore, it should describe any accessories, variants, or device configurations intended to be available on the market. Critical functional elements should also be detailed, including parts/components, materials used, and technical specifications.

In cases where the manufacturer has produced previous generations of the device or similar devices are available on the market, the technical documentation should provide an overview of these. This allows for comparing device iterations and similar products, providing valuable context for regulatory assessment and user understanding [19].

- **Information Supplied by the Manufacturer**

A device's technical documentation should have a complete set of labels on its packaging, including single-unit packaging, sales packaging, and transport packaging. These labels should be in the languages accepted in the Member States where the device is intended to be sold. Moreover, the documentation must include instructions for use in the accepted languages. All these elements are crucial to ensure that users can access the necessary information about the device's use, handling, and safety precautions [19].

- **Design and Manufacturing Information**

Complying with regulatory requirements and ensuring the quality of the device throughout its lifecycle requires technical documentation that includes detailed information about the device's design and manufacturing processes. This documentation should cover the design stages, complete specifications, manufacturing processes, and their validation; adjuvants used, continuous monitoring procedures, and final product testing. Moreover, it should identify all sites involved in design and manufacturing activities, including suppliers and subcontractors [19].

- **General Safety and Performance Requirements**

The technical documentation should contain information necessary to demonstrate conformity with the general safety and performance requirements in Annex I of the MDR [26]. This includes justifying, validating, and verifying the solutions adopted to meet those requirements. The

documentation should specify the general safety and performance requirements applicable to the device, explain why others do not apply, describe the methods used to demonstrate conformity with each applicable requirement, identify the harmonized standards or other solutions applied, and provide precise references to the controlled documents offering evidence of conformity. This information ensures that the device meets the necessary safety and performance standards for its intended purpose [19].

- **Benefit-risk analysis and Risk Management**

The technical documentation for a device must include information about the benefit-risk analysis and risk management process conducted for the device. This process involves evaluating the risks and benefits associated with the device's use and implementing appropriate risk management measures to address any identified risks. The documentation should clearly describe the solutions adopted and the results of the risk management process, assuring that the device's benefits outweigh its risks and that measures are in place to ensure its safe and effective use [19].

- **Product Verification and Validation**

The technical documentation for medical devices needs to contain the results and analysis of all verification and validation tests undertaken to demonstrate its conformity with the requirements of the MDR. This includes pre-clinical and clinical data, which should be presented in detail. Pre-clinical data may consist of results of engineering, laboratory, simulated use, and animal tests, as well as evaluation of published literature relevant to the device's safety and conformity with specifications. Clinical data should include the clinical evaluation report, post-market clinical follow-up plan and report, and justification for any absence of new testing [19].

Preparing technical documentation requires collaboration among various teams, including regulatory affairs, software development, quality assurance, clinical research, and legal compliance. Each team contributes expertise to ensure complete and accurate documentation.

### 3.3.3. Conformity Assessment Process

The Conformity Assessment Process is the procedure by which a manufacturer demonstrates that a medical device meets the applicable safety, performance, and quality standards as outlined in the MDR. This process is mandatory for all medical devices marketed in the European Union, including MDSW, and varies depending on the risk classification of the device. Two of the initial key steps in this process are the ones mentioned above: regulatory strategy and preparation of technical documentation. However, this process is more extensive and also includes the following steps:

#### 3.3.3.1. *Quality Management System*

A QMS is a structured framework of policies, processes, procedures, and resources established by an organization to ensure that its products or services consistently meet or exceed customer requirements and regulatory standards.

The chapter on QMS in the MDR outlines requirements for manufacturers to establish, implement, and maintain a quality management system to ensure the safety, performance, and compliance of their medical devices. Table 3.1 describes some of the requirements typically stipulated by the MDR regarding the QMS.

Table 3.1. Type of Requirements for a Quality Management System [19]

Type of Requirement	Document / Action	Description
<b>General</b>	Establishment and Maintenance	Manufacturers must establish, document, implement, maintain, and update a quality management system that meets the requirements of the MDR.
	Responsibilities	The manufacturer's management must be responsible for ensuring that the QMS is implemented and maintained effectively.
	Quality Policy and Objectives	Manufacturers should define and document their quality policy and objectives, ensuring they align with the company's strategic direction and comply with regulatory requirements.
<b>Specific</b>	Risk Management	The QMS should include processes for identifying, assessing, and controlling risks associated with the manufacture and use of medical devices, in accordance with ISO 14971.
	Design and Development	Procedures for the design and development of medical devices must be established, ensuring they are conducted in accordance with applicable regulatory requirements and standards.
	Clinical Evaluation	The QMS should include processes for conducting clinical evaluations of medical devices, ensuring that they are performed in accordance with the MDR's requirements.
	Supplier and Contractor Management	Manufacturers must establish procedures for selecting, monitoring, and evaluating suppliers and contractors to ensure they meet applicable regulatory requirements and quality standards.
	Production and Process Controls	Procedures for controlling production and manufacturing processes ensure that medical devices are produced in accordance with the MDR's requirements and meet specified quality standards.
	Control of Non-Conforming Products	Processes for identifying, segregating, and addressing non-conforming products must be established to prevent their unintended use or distribution.
	Corrective and Preventive Actions	Procedures for investigating and addressing non-conformities and implementing corrective and preventive actions to prevent their recurrence.

Type of Requirement	Document / Action	Description
	Document Control	Procedures for controlling the creation, review, approval, distribution, and maintenance of documents related to the QMS must be established to ensure that only current and approved documents are used.
	Record Keeping	Processes for establishing and maintaining records related to medical device manufacture, distribution, and post-market surveillance, ensuring they are complete, accurate, and readily retrievable.
	Internal Audits	Conduct regular internal audits of the QMS to verify its effectiveness and compliance with regulatory requirements, ensuring that any deficiencies are identified and addressed promptly.
	Management Review	The manufacturer's management must conduct periodic reviews of the QMS to ensure its continued suitability, adequacy, and effectiveness in achieving quality objectives and regulatory compliance.

Designated notified bodies of EU Member States are responsible for evaluating and certifying the QMS of medical device manufacturers to ensure compliance with the MDR. Additionally, competent authorities of EU Member States are responsible for monitoring the implementation and effectiveness of these QMSs through market surveillance activities. In cases of non-compliance, these authorities may take enforcement actions.

### 3.3.3.2. *Clinical Evaluation and Clinical Investigations*

Clinical Evaluation is a systematic and planned process for generating, collecting, analyzing, and assessing clinical data related to a device. Its purpose is to confirm the device's clinical safety and performance over its expected lifetime. Manufacturers must develop a robust clinical evaluation plan that outlines the methodology to be followed. This plan should detail how clinical data will be collected, what data is necessary to support safety and performance, and how it will be evaluated. The device's clinical efficacy assessment should rely on pertinent clinical data. This data can be obtained from clinical trials conducted on the device and from clinical studies or research papers on similar devices available in the scientific literature. Additionally, published or unpublished reports on clinical experiences with either the device in question or a comparable device can also be used to inform the clinical evaluation. All findings from the clinical evaluation must be documented in a Clinical Evaluation Report, which should be regularly updated to support device conformity assessment [19].

Clinical investigations are conducted to evaluate the safety and effectiveness of a medical device when there is insufficient clinical data to support its intended purpose. If the existing data is inadequate, the manufacturer must conduct a clinical investigation that is justified with clear objectives, planned outcomes, and designed following ethical considerations and regulatory requirements. Clinical investigations should adhere to relevant standards and ethical principles consistent with the Declaration of Helsinki. This includes obtaining necessary approvals from ethics committees and regulatory bodies,

ensuring informed consent from participants, and registering the clinical trial. Data from clinical investigations must be recorded, analyzed, and reported systematically. The results should be included in the technical documentation and the Clinical Evaluation Report [19].

After having all this information gathered and in compliance with the MDR, the Notified Body reviews the technical documentation, QMS, and clinical evaluation. If the Notified Body is satisfied that the device meets the MDR's requirements, it issues a CE marking certificate, allowing the device to be marketed in the EU [33].

Once the device has passed the conformity assessment, the manufacturer must issue a Declaration of Conformity. This is a formal statement that the device complies with all applicable MDR requirements. The Declaration of Conformity is a critical document in the product's technical file and must be maintained throughout the device's lifecycle [33].

### 3.3.4. Post-Market Surveillance and Vigilance

After placing the device on the market, ongoing post-market surveillance and vigilance are mandatory. This includes monitoring the device's performance in real-world use, reporting adverse events, and taking corrective actions when necessary. The Conformity Assessment Process requires manufacturers to establish and maintain a post-market surveillance system as part of their QMS. This system must be capable of detecting emerging risks and ensuring that any issues are promptly addressed [34].

# 4

## Navigating Regulatory Challenges

Proposed Regulatory Strategy Framework for MDSW

Navigating the regulatory landscape for MDSW is complex, particularly given the lack of a clearly defined framework to guide manufacturers. This section introduces a structured regulatory strategy framework to help manufacturers qualify and classify MDSW effectively. This framework aims to simplify the regulatory process by offering a systematic approach, making it more transparent and manageable for all involved.

### 4.1. Challenges in Qualification and Classification of MDSW

#### 4.1.1. Focal Issue

When developing the regulatory strategies for the products described in the Product Assessments section, during my internship with Compear, difficulties in determining the qualification and classification of the software were highlighted. This issue is complex, involving challenges in both qualification and classification due to the often-ambiguous nature of MDSW functionalities and the complex, sometimes inconsistent, application of regulatory rules. Integrating medical and non-medical features within a software product can further complicate its classification, leading to uncertainty and potential regulatory misalignment.

#### 4.1.2. Problem Analysis

The challenges of qualifying and classifying MDSW come from the following:

- **Functional Ambiguities.** Many MDSWs possess a mix of features, where some functionalities may align with medical purposes while others do not. This duality can confuse if the software qualifies as a medical device.
- **Interpretation of Rule 11.** Rule 11 of the MDR is intended to guide the classification of MDSWs. However, the rule includes several grey areas and lacks detailed guidance on specific aspects of software functionality. This ambiguity often leads to varying interpretations, resulting in inconsistent classifications and regulatory uncertainty. Manufacturers and regulatory professionals may struggle to apply Rule 11 uniformly across different scenarios, leading to potential misclassification.

#### 4.1.3. Identification of Problem Variables

Upon reviewing the information provided, it is evident that the variables include the product's features and functionalities and the ambiguities surrounding regulation.

The solution to this problem is to establish a framework that considers the individual features of the software rather than treating the software as a whole, as often particularities of the individual features are disregarded when assessing directly the software as a whole missing pertinent points that would qualify the software as a medical device. Additionally, it is important to provide clarity on key concepts in the regulation to reduce ambiguity.

### 4.2. Regulatory Strategy Framework

The framework developed supports the qualification and classification of MDSW as medical devices under the MDR; however, it does not extend to the qualification and classification of IVD medical devices. This distinction is crucial, as IVD classification depends more on the medical purpose,

focusing on diagnostic intent rather than the risk-based interpretation that is central to the classification of medical devices under the MDR.

For a better visualization of the framework, the pathways for class I and Class IIa or higher can be referenced in sources [35] and [36], respectively.

The proposed regulatory strategy framework for MDSW is designed to facilitate the systematic qualification and classification of such products. This framework comprises two principal components: product qualification and classification. The framework can be divided into three parts:

#### 4.2.1. Product Information

The initial phase of the regulatory strategy framework involves the manufacturer evaluating the software. This step is essential for establishing a clear and detailed understanding of the device's characteristics and intended use, which forms the foundation for its subsequent qualification and classification.

In this phase, the manufacturer must provide an extensive description of the device. This description should cover several key elements:

- **Commercial Name and Device Description.** Include the product's commercial name and a detailed description of its functionalities and design.
- **Intended User and Patient Population.** Specify the device's intended user (e.g., healthcare professionals or patients) and the target patient population for which it is designed.
- **Intended Purpose and Indications of Use.** Clearly state the device's intended purpose, including the medical conditions or symptoms it aims to address and the specific indications for its use.
- **Contraindications.** List any conditions or situations where the device should not be used to prevent potential patient harm.
- **Marketing Claims.** Document any claims made by the manufacturer regarding the device's benefits or performance.

Additionally, this section requires a list of the device's features. Unlike other regulatory strategy frameworks, this approach emphasizes listing all features and their variations, along with brief descriptions. This detailed feature list is effective in achieving accurate product qualification and classification. By focusing on individual features rather than the overall device, this method allows for a more explicit assessment of potential risks associated with each feature, thereby enhancing the reliability of the qualification and classification process.

#### 4.2.2. Feature Qualification and Classification

This second part of the framework consists of a qualification and classification assessment of the features listed in the previous step. This assessment is operationalized through a structured questionnaire consisting of twelve targeted questions, divided into three parts: medical purpose, action on data, and condition.

Each question in the questionnaire is accompanied by an explanatory note designed to address potential ambiguities that may arise during the process. Additionally, each response is directly

associated with a corresponding classification or indicating that the software does not qualify as a medical device.

It is noteworthy that this questionnaire draws upon established sources, including the European Commission's guidelines for software qualification and the IMDRF document on device and risk characterization. Both sources have been previously validated and serve as a foundation for the framework's development. Integrating these validated guidelines ensures the framework aligns with current regulatory standards and provides a MDSW qualification and classification tool.

#### 4.2.2.1. Medical Purpose

The initial segment of the questionnaire, consisting of six questions, is aimed at determining the medical purpose of the software. These questions are made to extract information regarding the intended use of the software, which is essential for ascertaining whether the software qualifies as a medical device. Here are the questions and their corresponding answers:

Table 4.1. Q1: Intended purpose of the feature (based on Decision steps for qualification of software as MDSW of MDCG 2019-11 [7])

1. Is the intended purpose of the feature any of the following?		
<b>Educational</b>	Outcomes are not to be used for a patient.	Not MD
		Class I
		Class IIa
		Class IIb
		Class III
<b>Administrative</b>	Examples, such as invoicing or staff planning, do not qualify as medical device software.	Not MD
		Class I
		Class IIa
		Class IIb
		Class III
<b>Populational Health</b>	Intended only to aggregate population data. Information not intended to provide direct benefits to an individual patient.	Not MD
		Class I
		Class IIa
		Class IIb
		Class III
<b>Health Purpose</b>	Intended to provide health benefits to individual patients.	Not MD
		Class I
		Class IIa
		Class IIb
		Class III

The first question – Table 4.1 – assesses whether the feature under evaluation's intended purpose qualifies it as a medical device. If the manufacturer selects the *Educational*, *Administrative*, or *Population Health* options, the feature does not meet the qualification criteria as a medical device. This is because, as previously outlined, these categories do not serve a direct patient benefit.

Table 4.2. Q2: Intended use environment of the feature (adapted from IMDRF - Medical Device Software: Considerations for Device and Risk Characterization [37])

2. What is the intended use environment?	
<b>Non-clinical Environment</b>	Home-use.

2. What is the intended use environment?	
<b>General Healthcare Environment</b>	It can be a primary care clinic, virtual primary healthcare, etc.
<b>Specialty Healthcare Environment</b>	It can be a hospital, specialty clinic, or virtual specialty healthcare.

Table 4.3. Q3: Level of progression/stage of the condition that the features deals (adapted from IMDRF - Medical Device Software: Considerations for Device and Risk Characterization [37])

3. What's the level of progression/stage of the condition?	
<b>Chronic condition</b>	A long-lasting health issue that typically persists for an extended period, often for the rest of an individual's life. These conditions usually develop slowly and can be managed but not cured. A condition has a matching Disease Coding (ICD-10 or ICD-11 code).
<b>Acute condition</b>	A health issue that arises suddenly and typically has a short duration. These conditions often require immediate medical attention but usually resolve entirely with appropriate treatment. A condition has a matching Disease Coding (ICD-10 or ICD-11 code).
<b>Healthy condition</b>	It is impossible to diagnose a specific condition or not intended to target a specific condition. To be considered a condition it has to have a matching Disease Coding (ICD-10 or ICD-11 code)

Table 4.4. Q4: Timing of medical intervention of the feature (adapted from IMDRF - Medical Device Software: Considerations for Device and Risk Characterization [37])

4. What is the timing within medical intervention?	
<b>Non-Medical</b>	Results will not lead to any medical intervention, meaning a medical diagnosis or treatment could/would not be performed at this stage. Intervention would be nonmedical if not disease-specific.
<b>Early</b>	Triage, prediction of future diagnoses, early investigations upon suspicious symptoms or information, physiological signal or medical image acquisition for use in diagnosis or treatment planning
<b>Midway</b>	Signal or image segmentation for use in diagnosis or treatment planning; routine monitoring of patient health for clinically relevant changes requiring further care and not including acute scenarios
<b>Late</b>	Optimal image-guided treatment plan or dosage for consideration; adjunct diagnostic recommendations or second checks; continuous glucose monitor output analysis automatically driving basal insulin dosage.

Questions 2, 3, and 4 -Table 4.2,Table 4.3 and Table 4.4 , respectively – do not have a direct qualification or classification outcome linked to their respective answers, as the responses to these questions do not sufficiently contribute to determining whether the feature qualifies as a medical device. While these questions may provide valuable context for the classification process, the range of possible

answers is too broad and lacks the specificity needed to definitively aid in the classification decision. However, it is important to retain these questions as they provide contextual information.

The next question is adapted from one of the European Commission's questionnaire inquiries. Answering this question necessitates understanding the definition of an accessory for a medical device. According to Article 2(2) of the MDR, this definition is as follows:

An accessory is *an article which, whilst not being itself a medical device, is intended by its manufacturer to be used together with one or several particular medical device(s) to specifically enable the medical device(s) to be used in accordance with its/their intended purpose(s) or to specifically and directly assist the medical device functionality of the medical device(s) in terms of its/their intended purpose(s)*. The MDCG additionally mentions that the *software accessory may be driving or influencing the use of a medical device*. Moreover, the instructions for use and other documentation provided by the manufacturer should contain details about the way the appropriate software and accessories should be selected.

Table 4.5. Q5: Accessory of a medical device (based on Decision steps for qualification of software as MDSW of MDCG 2019-11 [7])

5. Is the device an accessory for a medical device, according to Art. 2(2) of the MDR?		
<b>No</b>	Operates as a standalone software.	Not MD
		Class I
		Class IIa
		Class IIb
		Class III
<b>Yes</b>	An accessory is classified on its own. However, as an accessory, if it does not qualify as a medical device, it will fall into a Class I classification unless it is an accessory of active implantable devices, in which case they are classified as Class III.	Not MD
		Class I
		Class IIa
		Class IIb
		Class III

If the response to the fifth question – Table 4.5 – is no, the feature may or may not be considered a medical device. However, if the feature is identified as an accessory to a medical device, it is automatically qualified as a medical device. This is because accessories, given their essential role in ensuring the safe and effective operation of medical devices, are subjected to the same regulatory scrutiny as the devices they are designed to support.

Table 4.6. Q6: Health/Medical Purpose of the feature (based on Decision steps for qualification of software as MDSW of MDCG 2019-11 [7])

6. Is the feature's intended health/medical purpose any of the following?		
<b>Wellness</b>	Intended only for a general healthy lifestyle, wellness devices present a minimal risk to the user's and others' safety. This category includes fitness trackers, apps that track fitness and/or diet, exercise equipment, and video games without a medical claim.	Not MD
		Class I
		Class IIa
		Class IIb
		Class III
<b>Alleviation</b>	Improve the patient's condition by alleviating symptoms of a disease or disability and not treating the disease itself.	Not MD
		Class I
		Class IIa
		Class IIb
		Class III
<b>Prevention</b>		Not MD
		Class I

6. Is the feature's intended health/medical purpose any of the following?		
	Prevention in medical devices refers to integrating features and functionalities designed to avert potential health issues before they occur. The software used for disease prevention is classified as Class I.	Class IIa Class IIb Class III
<b>Compensation</b>	Improve a patient's condition by compensating for symptoms of a disease or disability by not treating the disease itself.	Not MD Class I Class IIa Class IIb Class III
<b>Prediction without treatment</b>	Identify patients at risk of developing a disease, thereby enabling prevention. If the outcome is preventive, it falls under Class I, which means it does not lead to a medical intervention (medical treatment). Prediction can often be confused with early prognosis.	Not MD Class I Class IIa Class IIb Class III
<b>Non-impact Prognosis</b>	Medical devices used for the prognosis of a disease are designed to predict the likely outcome or course of the disease once it is diagnosed. If the provided information on the progression of a disease, chances of recovery, and potential for complications <b>doesn't impact</b> a treatment or clinical decision, it will be classified as Class I.	Not MD Class I Class IIa Class IIb Class III
<b>Monitoring not for Diagnosis or Treatment</b>	It could fall under Class I if it is not used for diagnosis or if there is no vital threat. For example, if software monitors a physiological parameter based on which no diagnosis is proposed and which only indicates non-therapeutic actions, it could fall under Class I. A rather far-fetched example would be software monitoring the fluid balance and reminding the patient to consume fluids to support.	Not MD Class I Class IIa Class IIb Class III
<b>Decision-impact Prognosis</b>	Medical devices used for the prognosis of a disease are designed to predict the likely outcome or course of the disease once it is diagnosed. If the information on the progression of a disease, chances of recovery, and potential for complications impact a treatment or clinical decision, it will be classified as Class IIa or IIb.	Not MD Class I Class IIa Class IIb Class III
<b>Prediction with treatment</b>	Identify patients at risk of developing a disease, thereby enabling preventive (prophylactic) treatment. Leading to a decision to pursue preventive treatment (like breast surgery in high breast cancer risk patients), which falls under Class IIa / IIb.	Not MD Class I Class IIa Class IIb Class III
<b>Prevention for contraception</b>	Rule 15 applies to devices used for contraception or prevention of sexually transmitted diseases, which are classified as IIb.	Not MD Class I Class IIa Class IIb Class III
<b>Triage</b>	Triage is the process of prioritizing patients' treatments based on the severity of their condition. It helps manage patient flow and	Not MD Class I Class IIa Class IIb

6. Is the feature's intended health/medical purpose any of the following?		
	resources effectively, aiming to maximize the number of survivors and provide the most effective care.	Class III
<b>Screening / Detection</b>	Screening and detection refer to the processes used to identify diseases or medical conditions at an early stage, often before symptoms appear. Screening involves tests or examinations to detect potential health issues in asymptomatic individuals or at-risk populations.	Not MD
		Class I
		Class IIa
		Class IIb
<b>Support to Diagnosis or Treatment</b>	A device is considered to allow direct diagnosis when it provides the diagnosis of the disease or condition in question by itself or when it provides decisive information for the diagnosis. This means that even if a healthcare professional is responsible, any impact on the pathway to diagnosis would be considered. It can fall under Class IIa, IIb, or III depending on the impact of making decisions with diagnosis purposes.	Not MD
		Class I
		Class IIa
		Class IIb
<b>Monitoring Physiological Processes/Parameters for Diagnosis or Treatment</b>	Software intended to monitor physiological processes is classified as IIa, except if it is intended for monitoring of vital physiological parameters, where the nature of variations of those parameters is such that it could result in immediate danger, in which case it is classified as Class IIb.	Not MD
		Class I
		Class IIa
		Class IIb
		Class III
<b>Treatment Guidance</b>	Typically, it provides clinicians with data or imaging that supports them in making informed decisions on the appropriate interventions for a patient. An example of such a device is feedback measures from rehabilitation exercises effectiveness, to allow therapy adjustment.	Not MD
		Class I
		Class IIa
		Class IIb
		Class III
<b>Treatment Delivery</b>	These usually enable the delivery of medicine (i.e., a drug dosage calculator) or of the delivery of the treatment itself (i.e., Cognitive Behaviour Therapy).	Not MD
		Class I
		Class IIa
		Class IIb
		Class III

The sixth question, in Table 4.6, represents a pivotal point in the questionnaire, marking the transition from assessing the software's medical purpose to evaluating how the feature interacts with data.

The response provided by the manufacturer to this question determines one of three possible pathways. The software is not considered a medical device if the *Wellness* option is selected. If the response pertains to *Alleviation, Prevention, Compensation, Prediction without treatment or impact on prognosis, or Monitoring not intended for diagnosis or treatment*, the software qualified as a medical device and will likely be classified as Class I. If any other option is chosen, the software also qualifies as a medical device and is expected to fall under Class IIa or higher. However, it is essential to note that the possibility of the software not being qualified as a medical device is not entirely ruled out at this stage. The second part of the questionnaire must be completed to determine whether the software qualifies as a medical device under the MDR or remains as regular software with no specific regulatory obligations under the MDR.

4.2.2.2. *Action on Data*

The second part of the questionnaire comprises three questions focusing on the software's functional attributes, aiming to clarify each product feature's specific actions and interactions. These questions are fundamental for understanding the software's operational dynamics and potential impact on patient outcomes, which is essential in determining its classification as a medical device.

Based on the responses provided in the initial section, the questionnaire branches into two distinct pathways. If the manufacturer previously selected an option that suggests a Class I classification, the process will direct them down a specific route tailored to that classification. Alternatively, if the responses indicate a higher classification, such as Class IIa or above, the manufacturer will be guided along a different pathway designed for those categories. Although both pathways involve the same set of questions, the Class IIa or higher pathway includes additional or alternative answer options. The primary difference between these pathways lies in the broader range of possible classifications available in the higher classification pathway. The results from both pathways will be presented side by side for each answer.

Table 4.7. Q7: Feature's action on health data. (based on Decision steps for qualification of software as MDSW of MDCG 2019-11 [7])

7. What is the feature action on health data?		Class I Pathway	Class IIa or higher Pathway
<b>Storage / Archival</b>	This covers most Electronic Health Record functionalities.	Not MD	Not MD
		Class I	Class I
		Class IIa	Class IIa
		Class IIb	Class IIb
		Class III	Class III
<b>Lossless compression</b>	Conversion for specific file formats may not qualify for this exception, and such a device could qualify as a medical device.	Not MD	Not MD
		Class I	Class I
		Class IIa	Class IIa
		Class IIb	Class IIb
		Class III	Class III
<b>Simple search</b>	This concept raises more discussions, as the line for a simple calculation is not consensual across regulatory bodies. However, rankings where not all patients are visible and calculations that users cannot quickly validate, such as dosage calculations, do not fall within this exception.	Not MD	Not MD
		Class I	Class I
		Class IIa	Class IIa
		Class IIb	Class IIb
		Class III	Class III
<b>Communication</b>	It does not include time-relevant data, such as data for remote monitoring of critical conditions. Delays in communication are considered outside of this exception, as is often the case for alerts.	Not MD	Not MD
		Class I	Class I
		Class IIa	Class IIa
		Class IIb	Class IIb
		Class III	Class III
<b>Process, analyze, create, or modify health information</b>	All that does not fit the previous exceptions.	Not MD	Not MD
		Class I	Class I
		Class IIa	Class IIa
		Class IIb	Class IIb
		Class III	Class III
<b>Storage/ Archival. Lossless</b>		*	Not MD
			Class I

7. What is the feature action on health data?		Class I Pathway	Class IIa or higher Pathway
<b>compression, simple search, or communication but for real-time alerting</b>	If used for real-time monitoring, the time-sensitive aspect of the generated monitoring alerts will be considered processing and, thus, a medical device.		Class IIa
			Class IIb
			Class III

\*This answer does not apply to the Class I pathway.

Question 7, presented in Table 4.7, is critical in determining whether the software qualifies as a medical device. If any of the first four response options are selected, the software is likely excluded from being qualified as a medical device. If the option *Process, analyze, create, or modify health information* is selected, the software will most likely be classified as a Class I medical device within the Class I pathway. Depending on its specific use, the Class IIa or higher pathway may fall into one of the higher classifications. In either case, the software will likely qualify as a medical device since it generates or modifies information that could impact the user's condition. An additional possible answer is available in the Class IIa or higher pathway. This is because if the feature is used for storage, archiving, compression, simple search, or communication of data, and these actions are employed to monitor medical device data in real-time, the software will be considered Class IIa or higher. This classification is due to the time-sensitive nature of the monitoring involved. However, it is essential to note that this does not entirely rule out the possibility that the software might ultimately be deemed not to qualify as a medical device.

Table 4.8. Q8: Type of data processed by the feature (based on Decision steps for qualification of software as MDSW of MDCG 2019-11 [7] (Benefit of Individual Patient, Medical Device Definition))

8. What type of data does the feature process?		Class I Pathway	Class IIa or higher Pathway
<b>Medical Device Performance Indicators</b>	Informs on the quality and performance of a given device and its result. Unless used to drive or influence, the performance of a clinical purpose would lead to a medical device.	Not MD	Not MD
		Class I	Class I
		Class IIa	Class IIa
		Class IIb	Class IIb
		Class III	Class III
<b>Demographics</b>	Aggregated information that describes a population is not considered medical information.	Not MD	Not MD
		Class I	Class I
		Class IIa	Class IIa
		Class IIb	Class IIb
		Class III	Class III
<b>Lifestyle Indicators</b>	Lifestyle indicators that do not impact a medical purpose are not considered medical information. Examples include the number of partners and social risk behaviors.	Not MD	Not MD
		Class I	Class I
		Class IIa	Class IIa
		Class IIb	Class IIb
		Class III	Class III
<b>Personal Information</b>	Non-health personal data should be handled according to Regulation (EU) 2016/679 - GDPR.	Not MD	Not MD
		Class I	Class I
		Class IIa	Class IIa
		Class IIb	Class IIb
		Class III	Class III
<b>Health Indicators</b>	This can provide insight into an individual's disease risk, current health condition, or overall health	Not MD	Not MD
		Class I	Class I
		Class IIa	Class IIa

8. What type of data does the feature process?		Class I Pathway	Class IIa or higher Pathway
	status. It can also include personal information relevant to health, such as age and weight.	Class IIb	Class IIb
		Class III	Class III
<b>Physiological / Anatomy</b>	<p><b>Class I Pathway:</b> Measures of this data would classify the device at least as a Class Im. For instance, the measuring function for Class I medical devices with measuring function is considered for medical devices “which measure physiological parameters or anatomical parameter or energy, respectively, or volume of medicinal products, body liquids or other substances administered to or removed from the body and display or indicate its value in a unit of measurement (example: urine bags, non-active thermometers, measuring spoons). It can include imaging, laboratory, patient-reported, and movement data.</p> <p><b>Class IIa or higher pathway:</b> Any health-related data that supports the characterization of the patient's health.</p>	Not MD	Not MD
		Class Im	Class I
		Class IIa	Class IIa
		Class IIb	Class IIb
		Class III	Class III
<b>Vital Signals</b>	If used for real-time information that can lead to serious deterioration of health, it would qualify as a Class IIb; if not, it would be IIa.	*	Not MD Class I Class IIa Class IIb Class III
<b>In Vitro Samples – partially</b>	If <i>in vitro</i> data does not substantially drive the device's results, it is covered by MDR.	Not MD	Not MD
		Class I	Class I
		Class IIa	Class IIa
		Class IIb	Class IIb
		Class III	Class III
<b>In Vitro Samples - Mainly</b>	If <i>in vitro</i> data substantially drives the device's results, then it is covered by IVDR instead of MDR.	Not MD	Not MD
		IVD	IVD

\*This answer does not apply to the Class I Pathway.

The eighth question – Table 4.8 – holds particular significance, as understanding the type of data processed by the feature is crucial for evaluating its potential risk impact on a patient's condition or disease. Similar to the previous question, this inquiry provides further clarity regarding the qualification and classification of the feature. Notably, for the option "Physiological/Anatomy," the classification of Class I has been replaced with Class Im, as features that measure this type of data are generally classified under Class Im. As discussed in the classification section of the Literature Review, Class Im devices are subject to notified body procedures concerning the special function.

The "Vital Signals" option does not apply to the Class I pathway because any feature that involves the processing of vital signals is automatically classified to at least Class IIa due to the inherent risks associated with such data.

Additionally, it is important to note that the option "*In Vitro* Samples – Mainly," due to the significant influence this type of data has on the device’s outcomes, will be regulated under the *In Vitro*

Diagnostic Medical Devices Regulation (IVDR) rather than the MDR, as it follows a different classification system.

The following two questions determine whether the feature qualifies as a medical device. Although both pathways include the same two questions, the answers and the outcomes associated with those answers differ between the paths. Therefore, these questions will be divided into two sections to present the results according to each respective pathway.

**Class I Pathway**

Table 4.9. Q9a: Is the feature driving/influencing a MD? (based on MDCG 2019-11 [7], section 3.3. Software driving or influencing the use of a medical device)

<b>9a. Is the feature for driving/influencing a medical device?</b>	
<b>Yes, a class IIa or higher medical device</b>	
<b>Yes, a class I medical device</b>	
<b>No</b>	

Question 9, in Table 4.9, can yield three different outcomes based on the selected option. If the manufacturer indicates that the feature drives or influences a Class IIa or higher medical device, this response is considered invalid. In such cases, the manufacturer must revisit question 6, which addresses the intended purpose, as the chosen intended purpose is inconsistent with the intended use of the target medical device. If the response is that the feature drives or influences a Class I medical device, the feature itself is also classified as Class I. However, if the manufacturer states that the feature does not drive or influence a medical device, question 10 will then be presented to provide a more reliable determination.

Table 4.10. Q10a: Data processed by the feature easily verified. (based on the Manual on borderline and classification for medical devices under MDR [38])

<b>10a. Is the data processing (calculation/result) easily verified by the user?</b>	
<b>Yes</b>	Not MD
	Class I
	Class IIa
	Class IIb
	Class III
<b>No</b>	Not MD
	Class I
	Class IIa
	Class IIb
	Class III

Concluding the Class I pathway with question 10a, presented in Table 4.10, allows for a reliable decision regarding the feature's qualification and classification.

## Class IIa and higher Pathway

Table 4.11. Q9b: Is the feature driving/influencing a MD? (based on MDCG 2019-11 [7], section 3.3. Software driving or influencing the use of a medical device)

<b>9b. Is the feature for driving/influencing a medical device?</b>	
<b>Yes</b>	
<b>No</b>	

If the manufacturer indicates that the feature drives or influences a medical device, it automatically qualifies as a medical device and will be classified as Class IIa or higher. This classification is required because the feature must assume the risk classification of the medical device it influences or drives.

If the manufacturer selects the *No* option, this response alone is insufficient to make a definitive qualification decision, prompting the appearance of question 10 to provide further clarification.

Table 4.12. Q10b: Data processed by the feature easily verified. (based on the Manual on borderline and classification for medical devices under MDR [38])

<b>10b. Is the data processing (calculation/result) easily verified by the user?</b>	
<b>Yes</b>	Not MD
	Class I
	Class IIa
	Class IIb
	Class III
<b>No</b>	Not MD
	Class I
	Class IIa
	Class IIb
	Class III

Question 10 – Table 4.12 – is designed to clarify whether a feature qualifies as a medical device. A *No* response to this question allows for a conclusion that the feature does not meet the criteria to be classified as a medical device, thus resolving the qualification uncertainty. However, while this conclusion addresses the qualification aspect, it does not offer insight into the feature's classification within the regulatory framework.

This unresolved classification issue highlights a significant gap that necessitates the development of a third part of the questionnaire. Part three will be key to making a reliable conclusion about the feature's classification.

### 4.2.2.3. Condition

The third and final section of the questionnaire focuses on the influence of the feature's medical context and usage conditions, specifically aimed at determining whether the feature should be classified as Class IIa, Class IIb, or Class III. This questionnaire segment is designed to evaluate the risk associated with the feature and is employed exclusively to establish these higher classification categories. The classification for Class I features has already been addressed and determined in the earlier sections of the questionnaire dedicated to the Class I pathway.

The framework for this part of the questionnaire draws on Annex III of the MDCG 2019-11 guidelines, which provides indicative orientation on risk classification according to Rule 11 of the MDR. Annex III includes a table based on an IMDRF document related to a possible framework for risk categorization [37], that correlates the state of healthcare situations or patient conditions with the

significance of the information provided by the feature about diagnosis or therapy. This table helps assess and determine the appropriate risk class for the feature, offering a structured approach to classify the device according to its impact and relevance in clinical settings. An adaptation of the table can be reviewed in the Annex for further details.

Table 4.13. Q11: Risk /severity associated with incorrect feature performance. feature (adapted from IMDRF - Medical Device Software: Considerations for Device and Risk Characterization [37])

<b>11. What is the risk/severity associated with the condition or disease the software addresses? What is the potential impact of incorrect feature performance on patient safety?</b>		
<b>Non-serious condition Minimal impact</b>	It generally does not pose a significant risk to an individual's overall health or life. These conditions are usually mild, self-limiting, and can often be managed with minimal medical intervention. E.g. a minor inconvenience.	Class IIa
		Class IIb
		Class III
<b>Serious condition Moderate impact</b>	A health issue that poses a significant risk to an individual's overall health or life often requires immediate and exhaustive medical attention. Left untreated, these conditions can lead to severe complications, long-term health problems, or death. E.g. could lead to incorrect diagnosis or treatment	Class IIa
		Class IIb
		Class III
<b>Critical condition Severe impact</b>	Severe health issue that poses an immediate and extreme risk to an individual's life or primary bodily functions. These conditions typically require urgent and intensive medical intervention to stabilize the patient and prevent death or severe disability. E.g., could result in death or severe injury.	Class IIa
		Class IIb
		Class III

Answering question eleven – in Table 4.13 – significantly enhances the reliability of the classification result. Selecting the most appropriate option based on the feature's characteristics helps narrow down the possible classification outcomes. For instance, choosing the "Non-serious Minimal Impact" option will unequivocally classify the feature as Class IIa. Conversely, the other options may not yield a definitive classification as they could correspond to multiple classification possibilities. To ascertain the precise classification of the feature, question twelve is introduced, as shown in Table 4.14. The answer to question twelve is contingent upon the response to question eleven and the primary function of the feature within the medical device software. This ensures a more accurate and specific classification based on the full evaluation of the feature's impact and role.

Table 4.14. Q12: Primary function of the feature (adapted from MDCG 2019-11, Annex III [7])

<b>12. What is the primary function of the feature?</b>		<b>Nonserious condition Minimal impact</b>	<b>Serious condition Moderate impact</b>	<b>Critical condition Severe impact</b>
<b>Inform</b>	Provides information without immediate direct influence. Information is combined with other information that can replace or confirm medical decisions.	Class IIa	Class IIa	Class IIa
		Class IIb	Class IIb	Class IIb
		Class III	Class III	Class III
<b>Drive</b>	Directly influences decisions or actions based on information. Information is the main drive of medical decisions, given the	Class IIa	Class IIa	Class IIa
		Class IIb	Class IIb	Class IIb
		Class III	Class III	Class III

12. What is the primary function of the feature?		Nonserious condition Minimal impact	Serious condition Moderate impact	Critical condition Severe impact
	time or information limitations to use other sources of information.			
Treat or diagnose	Directly used to perform medical decisions. This includes the case of remote monitoring with an automated diagnosis of an acute condition (or its absence). Treatment indications without a medical doctor in the loop.	Class IIa	Class IIa	Class IIa
		Class IIb	Class IIb	Class IIb
		Class III	Class III	Class III

Addressing this final question in the questionnaire can definitively determine the feature's classification.

This process should be systematically applied to each feature identified in the initial stage of the framework – Product Information. Once this procedure has been completed for all listed features, the final component of the Regulatory Strategy Framework can be implemented.

#### 4.2.3. Classification Scenarios

Once all the individual features of the medical device software have been accurately qualified and classified, the next step involves aggregating these features to assess the most appropriate classification scenario for the software as a whole, while also considering the company's strategic objectives. This process is essential for determining whether the software qualifies as a medical device under the MDR when all intended features are combined and, if so, what its classification should be.

These classification scenarios serve as a valuable tool for evaluating whether the software, in its entirety, remains within the regulatory boundaries desired by the company. As discussed in the literature review, many companies developing healthcare-related software are startups or small to medium-sized enterprises. These companies often face substantial financial constraints, particularly regarding the costs associated with achieving and maintaining compliance with higher-risk classifications (Class IIa or above), which require engagement with a Notified Body. The fees and resources required for such regulatory processes can be prohibitive for smaller companies, potentially delaying their ability to bring innovative products to market.

The scenarios developed through this classification process enable companies to explore different combinations of features to determine which configuration best aligns with their regulatory and commercial objectives. For instance, if a company aims to avoid having its software qualified as a medical device, it must ensure that the combination of features does not include any that would individually qualify the software as a medical device under the MDR.

The classification of the entire software is considered to follow rule 3.5 of Annex VIII of MDR “If several rules, or if, within the same rule, several sub-rules, apply to the same device based on the device's intended purpose, the strictest rule and sub-rule resulting in the higher classification shall apply.”.

Therefore, if the company is willing to develop a Class I medical device, it can include features classified as Class I, understanding that this will subject the software to the regulatory requirements associated with this classification.

Moreover, if the company decides to include a Class IIa or higher feature, the entire software will adopt the feature's highest risk classification. This approach aligns with the regulatory principles outlined in the MDCG 2019-11 guidance document, which stipulates that the overall classification of a medical device software is determined by the highest classification assigned to any of its features. This ensures that the software, in its entirety, meets the necessary safety and efficacy standards associated with its most significant risks.

This systematic evaluation of scenarios not only aids in regulatory compliance but also supports strategic decision-making, allowing companies to balance innovation with regulatory feasibility and financial sustainability.

### 4.3. Practical Application of the Regulatory Strategy Framework: A Case Study on Telemedicine Platforms

To fully understand the practical utility of the Regulatory Strategy Framework outlined in this study, applying it to a real-world scenario is key. This application demonstrates the framework's effectiveness in navigating the complexities of MDSW regulation and underscores its value in resolving ambiguities that commonly arise in the classification and qualification process.

In the evolving landscape of digital health technologies, telemedicine platforms often find themselves in regulatory "grey zones." These platforms, which facilitate remote consultations, diagnosis, and patient monitoring, can present challenges in determining whether they meet the criteria for classification as a medical device under the MDR.

This section presents a case study of a fictitious telemedicine platform, Respirelink, from now on, to demonstrate the application of the proposed framework for determining its qualification and classification under the MDR. The case study introduces fictitious features associated with the platform, which are evaluated based on their respective risks. This hypothetical example is not based on any real product but is intended solely for illustrative purposes.

#### 4.3.1. Respirelink Information

##### **Commercial name and product description**

Under the commercial name Respirelink Advanced, this telemedicine platform is engineered to support remote healthcare services for individuals with chronic respiratory conditions. The platform offers integrated features for secure video consultations, electronic health record management, and real-time health monitoring. It is designed to facilitate remote interactions between healthcare providers and patients through various devices, including smartphones, tablets, and computers. RespireLink Advanced includes functionalities for monitoring vital respiratory parameters, scheduling appointments, and analyzing diagnostic data.

##### **Intended User and Patient Population**

RespireLink is intended for healthcare practitioners such as pulmonologists, general physicians, and respiratory therapists needing a telemedicine solution to manage patients with chronic respiratory diseases.

The platform targets patients diagnosed with chronic respiratory conditions, including Chronic Obstructive Pulmonary Disease and asthma. It is designed to support individuals who require regular monitoring and management of their conditions and benefit from remote healthcare services.

### **Intended Purpose and Indications for Use**

The purpose of RespirLink is to enhance the management and oversight of chronic respiratory conditions by offering a remote healthcare solution. It provides tools for virtual consultations, continuous health monitoring, and remote management of treatment plans.

RespirLink is used for:

- Conducting remote consultations and follow-up appointments with healthcare professionals.
- Monitoring respiratory health indicators, such as lung function and medication adherence, via integrated sensors.
- Accessing and reviewing patient medical records and diagnostic information in a secure manner.
- Facilitating the management of chronic respiratory conditions through remote care and data-driven insights.

### **Contraindications:**

RespirLink is not recommended for:

- Patients needing urgent or emergency medical care, as the platform is not designed to provide real-time emergency support.
- Individuals who do not have a diagnosis of chronic respiratory conditions, as the platform's features are specifically tailored to this patient group.
- Users who lack access to compatible devices or reliable internet connectivity, as the platform's efficacy depends on the ability to perform remote interactions and data exchanges.

### **Marketing Claims**

RespirLink elevates respiratory care with:

- **Remote Consultations.** Hassle-free consultations with your healthcare provider from your home.
- **Continuous Health Surveillance.** Monitor your respiratory health with our state-of-the-art monitoring tools. RespirLink provides real-time data on critical health metrics, helping your provider tailor your treatment for optimal results.
- **Enhanced Chronic Disease Management.** Specially designed for chronic respiratory conditions, RespirLink offers targeted solutions to support the management of COPD and asthma. The platform's tailored features help you achieve better health outcomes.
- **Technology for Better Care.** Leverage telemedicine technology to improve your respiratory health. RespirLink combines tools with actionable insights, empowering you to take an active role in managing your condition.

List of features

Table 4.15. List of features of RapidLink

#	Feature Name	Possible Variations	Short Description (including actions, purpose, inputs/outputs)
A.1	Virtual Consultations	-	<p><b>Action:</b> Facilitates video or audio consultations between patients and healthcare providers.</p> <p><b>Purpose:</b> To offer remote medical consultations and support without requiring physical visits.</p> <p><b>Input:</b> Communication tools for video/audio interactions.</p> <p><b>Output:</b> Consultation summaries and recommendations.</p>
B.1	Respiratory Monitoring	-	<p><b>Action:</b> Collects and processes self-reported data about respiratory symptoms from patients.</p> <p><b>Purpose:</b> To monitor and track changes in respiratory symptoms, helping to identify potential exacerbations early.</p> <p><b>Input:</b> Patient-reported symptoms.</p> <p><b>Output:</b> Trend analysis and alerts based on symptom patterns.</p>
C.1	Remote Lung Function Testing	Hardware Lung Function Testing	<p><b>Action:</b> Processes data from hardware connection.</p> <p><b>Purpose:</b> To estimate and monitor lung function remotely.</p> <p><b>Input:</b> Hardware data.</p> <p><b>Output:</b> Lung function metrics and trends.</p>
C.2		Standardized questionnaires for lung function testing	<p><b>Action:</b> Administers standardized questionnaires related to lung function.</p> <p><b>Purpose:</b> To estimate and monitor lung function remotely without direct hardware integration.</p> <p><b>Input:</b> Patient responses to symptom questionnaires and self-assessments.</p> <p><b>Output:</b> Feedback on lung function status and potential recommendations.</p>
D.1	Medication Adherence Monitoring	-	<p><b>Action:</b> Analyze medication adherence patterns based on logged data.</p> <p><b>Purpose:</b> To ensure that patients are following their prescribed medication regimen.</p> <p><b>Input:</b> Patient entries of medication use, including dosage and timing.</p>

#	Feature Name	Possible Variations	Short Description (including actions, purpose, inputs/outputs)
			<b>Output:</b> Feedback and reminders to improve adherence.
E.1	Remote Diagnostic Support	-	<p><b>Action:</b> Allows patients to upload and review medical records, test results, and self-reported health data.</p> <p><b>Purpose:</b> To facilitate remote review of diagnostic information and support healthcare providers in assessing patient health.</p> <p><b>Input:</b> Uploaded medical records, previous diagnostic test results, and self-reported data.</p> <p><b>Output:</b> No output.</p>
F.1	Emergency Response Alerts	-	<p><b>Action:</b> Sends alerts to emergency contacts based on pre-set thresholds or data trends.</p> <p><b>Purpose:</b> To ensure timely response in case of a medical emergency or significant health issue.</p> <p><b>Input:</b> Trigger events such as symptom thresholds or emergency settings configured by the patient.</p> <p><b>Output:</b> Emergency alerts sent to contacts and/or healthcare providers.</p>

It is important to delineate that the D.1 – Medication Adherence Monitoring feature generates reminders based solely on the prescribed medication leaflet provided by the user. The platform's reminders are designed to align with the general dosing instructions outlined in the medication's packaging. However, it is essential to emphasize that this feature does not offer personalized dosage recommendations tailored to the user's specific health characteristics or current state of condition.

#### 4.3.2. Feature Qualification and Classification

Having all the listed features in the tables below, it is possible to proceed to the qualification and classification.

Table 4.16. Application of the questionnaire to A.1 and B.1 features.

Question	A.1 Virtual Consultations	B.1 Respiratory Monitoring
	Answer	Answer
<a href="#">Q1</a>	Administrative	Health Purpose
<a href="#">Q2</a>	Non-clinical Environment	Non-clinical Environment
<a href="#">Q3</a>	Chronic condition	Chronic condition
<a href="#">Q4</a>	Midway	Midway
<a href="#">Q5</a>	No	No

<a href="#">Q6</a>	Monitoring not for Diagnosis or Treatment	Treatment Guidance
<a href="#">Q7</a>	Communication	Process, analyze, create, or modify health information
<a href="#">Q8</a>	Health Indicators	Health Indicators
<a href="#">Q9a</a>	No	No
<a href="#">Q9b</a>	-	No
<a href="#">Q10a</a>	Yes	-
<a href="#">Q10b</a>	-	No
<a href="#">Q11</a>	-	Serious condition - Moderate impact
<a href="#">Q12</a>	-	Inform
<b>Result</b>	<b>Does not qualify as a medical device</b>	<b>Class IIa medical device</b>

Table 4.17. Application of the questionnaire to C.1 and C.2 features.

Question	C.1 Hardware Lung Function Testing	C.2 Standardized questionnaires for lung function testing
	Answer	Answer
<a href="#">Q1</a>	Health Purpose	Health Purpose
<a href="#">Q2</a>	Non-clinical Environment	Non-clinical Environment
<a href="#">Q3</a>	Chronic condition	Chronic condition
<a href="#">Q4</a>	Midway	Midway
<a href="#">Q5</a>	No	No
<a href="#">Q6</a>	Treatment Guidance	Monitoring not for Diagnosis or Treatment
<a href="#">Q7</a>	Process, analyze, create, or modify health information	Process, analyze, create, or modify health information
<a href="#">Q8</a>	Vital Signals	Health Indicators
<a href="#">Q9a</a>	-	No
<a href="#">Q9b</a>	No	-
<a href="#">Q10a</a>	-	No
<a href="#">Q10b</a>	No	-
<a href="#">Q11</a>	Serious condition - Moderate impact	-
<a href="#">Q12</a>	Drive	-
<b>Result</b>	<b>Class IIa medical device</b>	<b>Class I medical device</b>

Table 4.18. Application of the questionnaire to D.1 and E.1 features.

Question	D.1 Medication Adherence Monitoring	E.1 Remote Diagnostic Support
	Answer	Answer
<a href="#">Q1</a>	Health Purpose	Administrative
<a href="#">Q2</a>	Non-clinical Environment	Non-clinical Environment
<a href="#">Q3</a>	Chronic condition	Chronic condition
<a href="#">Q4</a>	Midway	Midway
<a href="#">Q5</a>	No	No
<a href="#">Q6</a>	Treatment Guidance	Monitoring for Diagnosis or Treatment

<a href="#">Q7</a>	Process, analyze, create, or modify health information	Storage/Archival
<a href="#">Q8</a>	Health Indicators	Physiological / Anatomy
<a href="#">Q9a</a>	-	No
<a href="#">Q9b</a>	No	-
<a href="#">Q10a</a>	-	Yes
<a href="#">Q10b</a>	Yes	-
<a href="#">Q11</a>	-	-
<a href="#">Q12</a>	-	-
<b>Result</b>	<b>Does not qualify as a medical device</b>	<b>Does not qualify as a medical device</b>

Table 4.19. Application of the questionnaire to F.1 feature.

Question	F.1 Emergency Response Alerts
	Answer
<a href="#">Q1</a>	Health Purpose
<a href="#">Q2</a>	Non-clinical Environment
<a href="#">Q3</a>	Chronic condition
<a href="#">Q4</a>	Midway
<a href="#">Q5</a>	No
<a href="#">Q6</a>	Monitoring for Diagnosis or Treatment
<a href="#">Q7</a>	Process, analyze, create, or modify health information
<a href="#">Q8</a>	Health Indicators
<a href="#">Q9a</a>	-
<a href="#">Q9b</a>	No
<a href="#">Q10a</a>	-
<a href="#">Q10b</a>	No
<a href="#">Q11</a>	Serious condition - Moderate impact
<a href="#">Q12</a>	Inform
<b>Result</b>	<b>Class IIa medical device</b>

#### 4.3.3. RespiLink: Classification Scenarios

Table 4.20. Classification Scenarios for RespiLink

#	Scenario Description	Classification
S1	<b>COPD Management Platform</b>	<b>Not a medical device</b>
	This scenario enables remote healthcare consultations and facilitates the centralized storage of patient-uploaded information, ensuring that all relevant data is accessible in one location. This centralized platform is designed to streamline the workflow for healthcare professionals by consolidating patient information. Additionally, the system includes medication reminders, prompting patients to take their prescribed medications and allowing for tracking medication adherence. This feature helps healthcare providers monitor whether patients follow their prescribed treatment regimens effectively.	

#	Scenario Description	Classification
	<p><b>Assumptions:</b> The data uploaded is only used for administrative purposes or storage without any diagnostic or monitoring intent. The medication reminders are according to the medication’s leaflet.</p> <p><b>Features included:</b> <a href="#">A.1</a>, <a href="#">D.1</a>, <a href="#">E.1</a></p>	
S2	<b>Remote COPD Monitoring and Management</b>	<b>Class I</b>
	This scenario extends the previously outlined framework by incorporating standardized questionnaires designed for lung function assessment. Through these questionnaires, users receive feedback on their respiratory status and recommendations for effective preventative measures or compensatory actions to manage their condition.	
	<b>Features included:</b> <a href="#">A.1</a> , <a href="#">C.2</a> , <a href="#">D.1</a> , <a href="#">E.1</a>	
S3	<b>Remote COPD Monitoring</b>	<b>Class IIa</b>
	This scenario incorporates all the listed features, offering a tool for monitoring COPD patients. The software's integration with specific hardware commonly used in COPD management enhances the ability to gather detailed insights into the disease, which facilitates the identification of the most appropriate treatment pathway based on lung function status. Additionally, the integrated alert system enables quick intervention when established thresholds are exceeded, thereby improving the timeliness and effectiveness of patient care.	
	<b>Features included:</b> <a href="#">A.1</a> , <a href="#">B.1</a> , <a href="#">C.1</a> , <a href="#">C.2</a> , <a href="#">D.1</a> , <a href="#">E.1</a> , <a href="#">F.1</a>	

Outlining these scenarios – as seen in Table 4.20 – makes it significantly easier to visualize and comprehend the various developmental pathways that the software can undertake. Each scenario represents a strategic approach that aligns the software's functionality with regulatory requirements and the company’s broader business objectives.

For example, if RespiroLink's manufacturer lacks the necessary resources to enter the market as a Class I or higher medical device, opting for the S1 scenario becomes prudent. In this scenario, the software is deliberately limited to features that do not trigger medical device classification under the MDR. By ensuring that only non-medical device features are integrated, the company avoids the complexities and costs associated with regulatory compliance. This strategy simplifies the development process and reduces time-to-market, allowing the company to quickly establish a presence in the market. The decision to enter the market without being qualified as a medical device offers distinct competitive advantages. Without the burden of compliance costs – such as those associated with rigorous testing, certification, and ongoing regulatory oversight – the company can allocate resources more effectively toward marketing, customer acquisition, and product refinement. This approach also provides a valuable opportunity for the company to build a loyal user base, gather feedback, and refine its offering in response to user needs, all while avoiding the stringent regulatory landscape that typically accompanies medical device development.

As the company gains market traction and builds its brand, it may then consider incrementally expanding the software's capabilities. For instance, transitioning to a Class I medical device status could be a strategic next step. This classification is particularly attractive because it does not require the involvement of a notified body, making it a more accessible and cost-effective regulatory category. The self-certification process in Class I designation allows the company to maintain greater control over the development and certification timeline, facilitating a smoother and more efficient progression toward market readiness.

In the long term, if the company’s strategic goal is to offer a more complete tool for managing COPD, it may consider integrating higher-risk features that would elevate the software’s classification to Class IIa or beyond. However, this move would necessitate careful planning and resource allocation. The company would need to secure sufficient funding to cover the substantial costs associated with

notified body involvement, including extensive clinical evaluations, compliance audits, and potential redesigns to meet higher regulatory standards.

Furthermore, as the software's classification advances, the company must implement more robust post-market surveillance mechanisms and ensure ongoing compliance with stricter regulatory requirements. This could involve increased collaboration with healthcare professionals and continuous data monitoring to ensure the software remains safe and effective in real-world use.

In summary, by strategically selecting the appropriate scenario, RespiLink's manufacturer can manage regulatory risk, control costs, and align their product development with long-term business goals. The flexibility offered by these scenarios allows the company to adapt to changing market conditions, technological advancements, and regulatory updates, thereby positioning itself for sustained growth and success in the competitive healthcare technology market.

#### 4.4. Final thoughts

As previously discussed, the qualification and classification of MDSW under the MDR have become progressively complex, particularly with the transition from the MDD to the MDR. This shift has introduced more stringent requirements and a broader definition of a medical device with a "medical purpose," leading to more significant regulatory uncertainty.

The new MDR criteria have heightened the scrutiny of software, resulting in potential delays and increased compliance costs. The framework developed in this thesis offers a structured approach to navigate these complexities, providing manufacturers with clear guidance on qualification and classification. By systematically applying this framework, manufacturers can achieve greater clarity, ensure accurate classification, and enhance compliance with the MDR, thus facilitating more effective market access.

The development of the regulatory strategy framework has clarified the significant challenges associated with attaining Class I status for MDSW under the MDR. The MDR has introduced more stringent criteria than the MDD, resulting in reclassification of many software products. Previously, software that might have been classified as Class I under the MDD may now be categorized into higher-risk classes due to its intended purpose and associated risks.

One major challenge is the increased scrutiny regarding the software's role in clinical decision-making. For software to maintain Class I status, it must demonstrate a low level of risk to patients. However, as the software's functionality expands – particularly in areas such as processing physiological data, generating diagnostic information, or supporting treatment decisions – the risk profile of the software is likely to increase. This heightened risk often necessitates reclassification into a higher category, which requires oversight from a notified body.

Consequently, achieving Class I status for MDSW has become increasingly rare under the MDR's stringent regulations. As a result, such classifications may become exceptional, reflecting the rigorous standards imposed by the current regulatory framework.

Amongst these evolving regulatory considerations, addressing specific concerns related to the current compliance of medical device software in Portuguese hospitals is necessary. The transition from the MDD to the MDR has raised questions about how well existing software systems align with the new regulatory standards. As the next chapter explores, these concerns are particularly relevant in assessing whether Portuguese manufacturers are effectively managing and implementing the updated regulations for medical device software, ensuring that their systems remain compliant and adequately safeguard patient health.

# 5

## Compliance of MDSW in Portuguese Hospitals

This chapter provides an evaluation and discussion regarding the compliance of MDSW within Portugal's regulatory framework. It begins with an overview of the country's regulatory situation. Subsequently, the chapter delineates the research methodology employed, including the selection criteria for the software analyzed, the data collection processes, and the techniques used to assess compliance. The results of this research will then be presented, offering an analysis of the findings. These findings will be critically examined to identify patterns of compliance and non-compliance, as well as to understand the underlying factors influencing these trends. The chapter concludes with a discussion of the implications of these results for the broader landscape of MDSW regulation in Portugal and provides insights into potential areas for further research.

## 5.1. Regulatory Environment for MDSW in Portugal

The medical device regulation landscape in Europe is undergoing a significant transformation with the introduction of the MDR. Despite the promise of improved safety and performance standards, the implementation of MDR has been fraught with challenges and delays. Authorities across Europe, including INFARMED, have reported difficulties responding to the sheer volume and complexity of the new regulations.

Surveys conducted by the European Association of Medical Devices Notified Bodies (Team-NB) and the European Commission highlight substantial setbacks in the certification process due to a lack of Notified Bodies personnel resources to meet the increased demands of the MDR and a slow rate of submission for the needed certification by manufacturers. Because of this, a series of extensions for legacy devices were applied, allowing for up-classified medical devices to continue in the market under the previous 93/42/EEC Directive for Medical Devices, with a deadline of up to 2028 to complete the transition, if already meeting some regulatory requirements in the meantime [39].

Qualifying and classifying MDSW under the MDR involves critical considerations that measure the safety and quality of these digital products. Adding to this framework, specific registration procedures are mandated for medical devices in Portugal, contingent upon their classification and the manufacturers' location:

- Portuguese manufacturers or their representatives of Class I medical devices are required to notify INFARMED of their activity, in compliance with in compliance with the new law “Decreto-Lei n.º 29/2024, de 5 de abril”.
- For Class IIa, IIb, III, and active implantable medical devices, regardless of where the manufacturer is based, notification to INFARMED is obligatory, consistent with Article 11(3) of the same decree-law [40].

Portugal is often referred to as a pioneer in the adoption of Digital Health [41], with a large ecosystem of software manufacturers targeting Healthcare solutions. However, Portugal has a low amount of traditional medical device manufacturers, thus creating a perfect environment for the proliferation of MDSW that is not compliant with the MDR since the experience of manufacturing medical devices in the country is relatively low and mainly dominated by multinational companies with local sales activities. Also, in Portugal, the status of the new law related to MDR is somewhat in limbo, with the national legislation pending approval after consecutive political crises, leading to legal confusion as an old national law describing direct rules is to be read in light with a European Regulation that takes precedent in most of the requirements.

It is without surprise that stakeholders, namely healthcare professionals, and patients, used to freely use any software made available, and manufacturers, emerging from an industry without many regulatory requirements until recently [42], present low awareness of software as a medical device, and

the requirements to make such products made available to be used. At the same time, the generic requirement for CE Mark, not only to enter the European Economic Area but also other countries that recognize it, is a significant incentive to pursue the self-certification route as Class I [43], given that clients may not go in-depth to ensure a proper classification was taken into account unless they have references from competitor devices.

Considering these developments, a body of research will investigate the extent of compliance with the MDR. There is a distinctive lack of country-specific data to carefully assess the state of MDR implementation and compliance at the national level, in particular concerning software. This gap in the literature serves as a precursor for this investigation into software manufacturers in Portugal's efforts to comply with the new MDR framework.

Studies on the level of compliance of medical device manufacturers to regulatory requirements are limited, especially in comparison to the pharmaceutical industry. This is primarily due to the decentralized nature of the regulatory process in the EU, where the core actions are performed by (as current date) 42 independent Notified Bodies, in contrast to the more centralized system in the US, where the FDA maintains extensive databases. This allows more concrete research can be done on this topic of compliance. As an example, a recent study showed how AI-based software manufacturers fail to comply with US FDA regulation, with a significant level of mismatch between the products made available in the market, and those they seek approval from the FDA in the first place [44].

The establishment of the European Database on Medical Devices (EUDAMED) is a cornerstone in this transformation, aiming to enhance the transparency and coordination of information regarding medical devices available on the European market [45]. As of the current date, the full functionality of EUDAMED remains in development, with implications for the timely and effective exchange of information pertinent to medical device compliance. Thus, even the European Commission and National Competent Authorities face limitations on access to data to drive their policies regarding industry compliance, often limited to surveys to grasp the market status.

As a result, the current national Portuguese registration requirements for medical devices continue to be relevant, with existing databases operating as a provisional solution for medical device oversight. At the same time, national requirements for Public Hospitals to annually report on the software used to deliver more accessible healthcare, offer a unique registry of potential medical device software available in Portugal. This created a unique opportunity for a first-in-Europe study of the level of compliance to MDR in a particular geography, which can support further research in other European countries and understand the reality of compliance with European Laws to ensure safe and quality medical devices in place to protect all citizens.

## 5.2. Methodology

A mixed-methods approach was utilized to facilitate a thorough evaluation of medical device software compliance with the MDR. Portugal was deliberately selected for this study due to the availability of national registries that offer an extensive overview of the MDSW currently in use within the country.

### 5.2.1. Data Collection

During the research, documents were reviewed from various Portuguese public hospitals and small- and medium-sized enterprises' databases. Additional research was conducted using Google search. The methodology was carried out in several stages, as outlined below:

- **Collection of hospital reports**  
Data was collected from the *Relatório Anual Sobre o Acesso a Cuidados de Saúde* (Annual Report on Access to Health Care) of Portuguese public hospitals. Although these reports were intended to be publicly accessible, not all hospitals had released this information. Among the healthcare institutions surveyed, 38 reports were obtained, offering valuable insights into the software utilized in healthcare settings.
- **Database inquiry**  
Companies operating within the Portuguese healthcare market were researched using SME databases to provide a better perspective on their software solutions.
- **Google search queries**  
A series of targeted Google searches were conducted to expand the repository of MDSW. The searches included specific Portuguese terms that translated to “Hospital Artificial Intelligence,” “Software patient doctor alert,” “Patient management software,” “Doctor decision support software,” and “Hospital decision support software.” These queries were designed to uncover additional MDSW that might not have been reported in official documents or databases but are actively marketed or utilized in healthcare settings.

### 5.2.2. Data Curation and Processing

The initial collection yielded 1645 software entries from hospital reports, SME databases, and Google searches. However, many of these entries were duplicates, as multiple hospitals used the same software. This highlighted the interconnected nature of healthcare networks and shared software solutions. The duplicates were removed to ensure that the dataset was clean and accurate, leaving 625 unique software entries for in-depth analysis.

After cleaning the dataset, an investigation was conducted to confirm the market presence and availability of the unique software identified. This step was fundamental in validating whether the software solutions were mentioned in the reports and actively available and potentially used in the market. It also helped eliminate any software that may have been phased out, replaced, or incorrectly reported but still included in the hospital reports. This verification helped streamline the list, resulting in 599 software entries confirmed as currently available in the market.

Although significant efforts have been made to identify duplicate entries carefully, some similar software solutions with slightly different names or versions may have yet to be noticed, leading to potential underestimation of duplicate entries. Additionally, discrepancies in reporting styles across various sources and regions may have contributed to difficulty discerning duplicates from distinct software offerings.

### 5.2.3. Identification of potential MDSWs

The dataset containing the 599 records was analyzed to identify which products could be qualified as medical device software according to the framework established in Feature Qualification

and Classification. To accomplish this, publicly available sources like official websites, recent brochures, and product descriptions were explored to gather comprehensive information about the software's functions and intended uses. The software's clinical applications were considered, mainly if they involved diagnosis, prevention, monitoring, treatment, or alleviation of diseases, conditions, or injuries.

In this analysis, IVD software, encompassing a diverse array of pathology solutions, was excluded. This exclusion was motivated by the inherent challenges in accurately analyzing the precise features of IVD software. Moreover, compliance with the IVDR falls beyond the purview of this study.

During this qualification process, attention was paid to identifying the origins of the MDSW manufacturers, distinguishing between Portuguese manufacturers and multinational ones, and focusing on the quality of information of the first. This distinction was important for understanding the regulatory compliance requirement about local registration requirements because it would only be possible to access full-detail multinational companies with large portfolios of products with a centralized registration database such as the one existing for Portuguese manufacturers. Assuming that multinational manufacturers' products would be compliant in their origin countries if their CE Mark certificate could not be found, the assessment regarding compliance wasn't done. Portuguese manufacturers' products were not considered Compliant Medical Devices if their materials and Infarmed database lacked information on the CE Mark.

In cases where information about a given product was lacking, a cautious approach was adopted, refraining from drawing premature conclusions. Subsequently, such instances were systematically excluded from the analysis, excluding 482 products from the dataset.

Figure 5.1 provides a concise overview of the various steps involved in the methodology. It also highlights the significant outcomes that are obtained as a result of each of these steps.

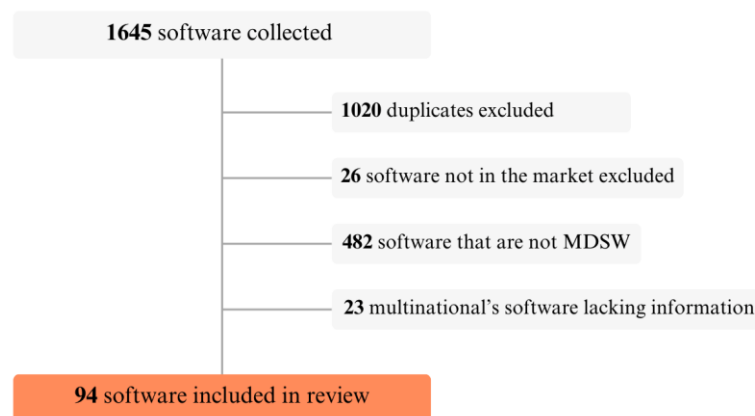


Figure 5.1. Flowchart of the selected software for review

#### 5.2.4. Medical Device Software Classification Process

To classify the 94 medical device software products, the approach outlined in the section on Feature Qualification and Classification was employed to ensure accurate and consistent categorization.

In cases where manufacturers did not explicitly provide classification details, the classification was assumed based on the highest potential risk category relevant to the software's intended use, as per criteria outlined in Annex VIII of the MDR. This approach was adopted to mitigate the risks associated with the potential underclassification of software and maintain a high regard for patient safety in compliance assessments.

To ascertain regulatory compliance, searches were conducted on INFARMED's database to verify whether the MDSWs had been duly registered and whether the information provided in the certificate corresponded to the pre- or posterior MDR time.

### 5.3. Results

#### 5.3.1. From Entries to Products & Qualified Medical Device Products

Following the analysis of the intended uses and functionalities of the 625 software entries, 94 have been categorized as MDSW. Only 47 instances of MDSW were reported to be in use during the analysis period within hospital settings, while 47 were identified in the markets. Many of these would also be expected to be used in those settings, even if there is no official report from them.

Of the 94 MDSW, 18 are manufactured by multinationals, with the remaining 76 originating from Portuguese manufacturers.

#### 5.3.2. Compliance Results (correct qualification, correct classification, correct registration) for National and International Products

Table 5.1 presents an analysis of how manufacturers reported the classification of their medical devices in relation to the expected classifications. It provides insights into the number of software instances that align with their reported classification and those that deviate from the anticipated categorization.

Table 5.1. Manufacturers' Reported Classification versus Expected Classification

Manufacturer	Expected Classification	Manufacturers' Reported Classification				
		Not a MD	Class I	Class IIa	Class IIb	Unknown
Portuguese	Class I	6	3	-	-	
	Class IIa	25	15	6	-	
	Class IIb	9	6	-	2	
Multinational	Class I	-	-	-	-	2
	Class IIa	1	-	12	-	12
	Class IIb	-	1	-	4	6

Note: No Class Im and Class III were identified.

Upon analyzing Table 5.1, a noteworthy observation indicates that its manufacturers do not acknowledge a significant portion of Portuguese software as a medical device. Contrarily, most 25 instances should be appropriately classified as Class IIa. Furthermore, 15 software products classified as Class I should be reclassified as Class IIa. It is essential to note that this analysis does not factor in the potential ongoing processes for obtaining a new CE Mark, considering the existing transition period to the MDR and the reported delays in assessments by Notified Bodies.

Table 5.2 delineates the outcomes resulting from the analysis of MDSW compliance with the EU MDR. The compliance levels are differentiated into several categories. The *Compliant* category encompasses MDSW that fully adhere to the EU MDR. The *Eligible for Transition from MDD to MDR* category includes software previously adhered to the MDD. Still, it now necessitates a shift in focus to align with the EU MDR. Despite being registered therein, the *Minor Non-Compliance Formalities* category comprises software lacking a visible CE Mark in the INFARMED's Database. The *Lacks CE Mark* and *Invalid CE Mark* categories denote non-compliance with the EU MDR. An *Unknown* category is included, encompassing software for which the current regulatory path isn't easily accessible.

Table 5.2. Compliance of Portuguese and Multinational MDSW with the EU MDR

	Portuguese Manufacturer		Multinational Manufacturer	
	Total	In Hospital Use	Total	In Hospital Use
Compliant	6		7	5
Eligible for Transition from MDD to MDR	12	5	1	1
Minor Non-Compliance Formalities	3		9	9
Lacks CE Mark	40	26		
Invalid CE Mark	11	3		
Unknown	3		20	20

A notable distinction surfaces between the software of Portuguese manufacturers and that of multinational entities. Specifically, 52 software instances from Portuguese manufacturers demonstrate non-compliance with the EU MDR. Conversely, there is a higher count of Portuguese software eligible for the transition from the MDD to the EU MDR, underscoring a noteworthy contrast between the compliance statuses of these two groups.

Table 5.3. Compliance of Portuguese and Multinational MDSW as per classification reported in Infarmed Database

	Portuguese Manufacturer			Multinational Manufacturer		
	Class I	Class IIa	Class IIb	Class I	Class IIa	Class IIb
Compliant	1	5			5	2
Eligible for Transition from MDD to MDR	8		1	1		
Minor Non-Compliance Formalities	1	1	1		7	2
Invalid CE Mark	11					

The analysis reveals that, among Portuguese Manufacturers, non-conformity predominantly lies within incorrect classification as Class I. In contrast, multinational companies exhibit minor non-compliance formalities in Class IIa and Class IIb, with no non-conformities detected in Class I.

## 5.4. Discussion

According to the initial analysis conducted, 85% of medical device software produced by Portuguese manufacturers is not being classified properly, following the guidelines set out for

qualification and classification. Furthermore, a second analysis has shown that 68.4% of these devices are not compliant with the MDR. Upon closer inspection, it appears that most of the devices flagged for non-compliance are guilty of minor formalities and possessing an invalid CE marking.

Around 15.8% of medical devices in Portugal are required to transition from the Medical Device Directive to the Medical Device Regulation. Among these devices, most belong to class I and must be up-classified to class IIa. Despite being now classified as a higher-risk class under the MDR, the affected devices are still compliant with regulations because responses from notified bodies are currently delayed. However, it's important to note that these devices must have declared conformity before May 2021, comply with Article 120 of the MDR, and had submitted an application to notified bodies until May 2024 to remain eligible for sale.

These results show that medical device software compliance is not being done correctly. The findings indicate that the current methods of ensuring compliance with medical device software are inadequate, with several discrepancies and gaps being identified. These lapses can lead to severe consequences, including patient harm and safety risks. Despite the inherent challenges faced by Competent Authorities in managing their resources effectively, it's important to ensure compliance with medical device software. Implementing more robust measures, including enhanced quality control mechanisms and regular audits, may be beneficial. Such proactive steps would facilitate the timely identification and rectification of any issues that may arise. Such actions will go a long way in promoting patient safety and ensuring medical device software meets the necessary standards.

# 6

## Final Remarks

During my internship at Compear, working on regulatory strategies for various companies highlighted a significant need for a more structured and reliable method for qualifying and classifying MDSW. It became evident that relying solely on the primary intended purpose of the software is insufficient for accurate qualification and classification. For instance, using the Telemedicine Platform as an example, if the software only provided video consultations, it would not typically be qualified as a medical device. However, it would be qualified as a medical device if it included additional features such as real-time lung function status. These uncertainties and potential misclassifications highlighted the need for a more wide-ranging approach.

To address this challenge, a regulatory strategy framework was developed, drawing on established guidelines from the European Commission and the IMDRF. The framework employs a feature-by-feature approach to qualification and classification, enhancing accuracy and reliability. By assessing each feature individually, the framework provides a detailed understanding of its primary function and intended purpose. Following this evaluation, features are grouped to create classification scenarios. This method clarifies the regulatory pathway and offers valuable insights for both regulatory professionals and potential investors. It facilitates a more informed decision-making process regarding product strategy, aligning with the company's resources and objectives.

In light of these insights, an assessment was conducted to determine whether MDSWs used in Portuguese hospitals comply with the MDR. The assessment revealed that nearly 70% (68.4%) of the MDSWs in use are not compliant with the new regulations. This finding highlights the urgent need for enhanced regulatory oversight and concerted efforts to address these compliance issues. It underscores the necessity for continuous adaptation to the evolving regulatory landscape to ensure that all MDSWs meet the stringent standards set by the MDR.

The development of the Regulatory Strategy Framework represents a significant advancement for both the Regulatory Affairs community and manufacturers seeking clarity in the qualification and classification of MDSW. By providing a structured approach to feature-by-feature evaluation, this framework addresses the complexities and ambiguities inherent in the regulatory process. It offers manufacturers a more precise methodology for determining the regulatory status of their products, thus facilitating compliance with the MDR and streamlining the path to market authorization.

Furthermore, the compliance assessment of MDSW used in Portuguese hospitals has unveiled critical insights into the current state of regulatory adherence. The findings indicate that many of these software products are not meeting MDR standards, highlighting a gap in oversight that INFARMED currently lacks the resources to fully address. This situation underscores the necessity for a more rigorous regulatory framework and enhanced scrutiny of MDSW within a hospital setting.

The implications of these findings are profound, as they emphasize the need for stricter regulation and better enforcement to ensure the safety and efficacy of MDSW. Given that such software plays a pivotal role in patient care, it is essential to uphold high standards to prevent potential risks associated with inadequate or non-compliant software. Ultimately, improving regulatory practices will safeguard patient welfare and enhance the reliability of medical device software, ensuring that all stakeholders – including patients, healthcare providers, and regulatory bodies – benefit from safer and more effective technologies.

Exploring the regulatory strategy subject for MDSW presented considerable challenges, primarily due to the inherent complexities and the vast scope of information required to make informed decisions. Regulatory Affairs is often characterized by its "grey zones," where clear-cut answers are elusive, and decisions frequently depend on many contextual factors. This sentiment was echoed by professionals at the event RAPS Euro Convergence 2024 in Berlin, where a common refrain was that almost everything in regulatory affairs "depends on something". The absence of straightforward,

universally applicable guidelines creates an environment where answers are rarely definitive and where the context is essential for providing accurate and compliant advice to manufacturers.

One of the key challenges in developing a "well-defined" Regulatory Strategy Framework lies in its inherent contradiction to this dependency-driven nature of regulatory decision-making. The idea of creating a structured and reliable framework that can be broadly applied is at odds with the reality that regulatory decisions often rely on nuanced interpretations of regulations, specific product contexts, and evolving guidelines. Yet, this framework offers a more systematic approach, striving to reduce the uncertainty and variability that typically accompany the qualification and classification processes.

The compliance assessment of MDSW used in Portuguese hospitals also encountered significant obstacles. A major challenge was the scarcity of detailed information online for many of the evaluated software products. This lack of transparency posed a significant limitation to the study, as the application of the developed framework necessitated knowledge of the features and functionalities of each MDSW. Without sufficient data, the accuracy and reliability of the assessment were compromised, underscoring the difficulties faced when applying rigorous regulatory frameworks without detailed product information.

The findings and challenges encountered in this study point to several key areas where further research is necessary and potentially impactful. The development and implementation of a Regulatory Strategy Framework for MDSW under the MDR is still beginning, and there remains a substantial need to refine and validate these tools to ensure their applicability across a wide range of software products. Future research should focus on the following areas:

- **Validation and Testing of the Framework.** While the framework developed in this study offers a systematic approach to qualifying and classifying MDSW, its effectiveness must be validated across a broader spectrum of software types and use cases. Subsequent research should involve testing the framework in various real-world scenarios, encompassing diverse medical conditions, software functionalities, and regulatory environments. This would help to identify potential limitations and areas for improvement, ensuring that the framework is robust, versatile, and applicable to a wide array of software products.
- **Automation and AI in Regulatory Compliance.** As the complexity of regulatory requirements continues to grow, there is an increasing need for automated tools to assist in the qualification and classification of MDSW. Future research should explore the integration of AI and machine learning algorithms into the regulatory framework, potentially enabling more efficient and accurate assessments. These technologies could help streamline the decision-making process, reduce the likelihood of human error, and provide real-time updates as regulatory guidelines evolve.

Working in this field has significantly deepened my appreciation for the complexities and challenges faced by professionals in Regulatory Affairs. The process of qualifying and classifying MDSW extends far beyond the mere assignment of regulatory risk classes; it is a critical phase in the certification process that has profound implications for both industry and public health. Effective qualification and classification not only streamline the path to market, reducing the time and financial resources required for compliance, but they also play a crucial role in safeguarding human health. Misclassification of software can result in significant risks, as occasionally reported in the media.

This newfound understanding of the importance of these processes underscores the vital role that Regulatory Affairs professionals play in ensuring that all products meet rigorous regulatory standards, thereby protecting public safety. The work these professionals undertake is essential in maintaining the integrity of the healthcare system and ensuring that medical devices contribute positively to patient outcomes.

## Bibliography

- [1] “Medical devices and technology across the years,” Yale Medicine Magazine. Accessed: Apr. 02, 2024. [Online]. Available: <https://medicine.yale.edu/news/yale-medicine-magazine/article/medical-devices-and-technology-across-the-years/>
- [2] “A History of Medical Device Regulation & Oversight in the United States | FDA.” Accessed: Apr. 02, 2024. [Online]. Available: <https://www.fda.gov/medical-devices/overview-device-regulation/history-medical-device-regulation-oversight-united-states>
- [3] M. Cheng, “An Overview of Medical Device Policy and Regulation,” 2007. [Online]. Available: [www.ghtf.org](http://www.ghtf.org)
- [4] M. Fink and B. Akra, “Comparison of the international regulations for medical devices-USA versus Europe ☆,” *Injury*, vol. 54, p. 110908, 2023, doi: 10.1016/j.injury.2023.110908.
- [5] EUPATI, “Introduction to Medical Devices and their regulatory framework: 3. History of Medical Device regulatory framework in the EU | EUPATI Open Classroom.” Accessed: May 28, 2024. [Online]. Available: <https://learning.eupati.eu/mod/page/view.php?id=928>
- [6] “MDR - Article 2 - Definitions - Medical Device Regulation.” Accessed: May 28, 2024. [Online]. Available: <https://www.medical-device-regulation.eu/2019/07/10/mdr-article-2-definitions/>
- [7] Medical Device Coordination Group Document, “MDCG 2019-11 Guidance on Qualification and Classification of Software in Regulation (EU) 2017/745 - MDR and Regulation (EU) 2017/746 - IVDR,” 2019.
- [8] “Software as medical device: definition and classification.” Accessed: Jun. 26, 2024. [Online]. Available: <https://blog.johner-institute.com/iec-62304-medical-software/software-as-medical-device-definition-and-classification/>
- [9] “Software as a Medical Device - tracekey solutions GmbH.” Accessed: Jun. 26, 2024. [Online]. Available: <https://www.tracekey.com/en/software-as-a-medical-device/>
- [10] A. Dennis, “To be, or not to be (a medical device): when does software qualify as a medical device?” Accessed: Aug. 13, 2024. [Online]. Available: <https://www.taylorwessing.com/en/insights-and-events/insights/2023/02/software-and-medical-devices-to-be-or-not-to-be>
- [11] “Software as a Medical Device Market.” Accessed: Aug. 13, 2024. [Online]. Available: <https://www.factmr.com/report/software-as-a-medical-device-market>
- [12] S. Reddy, J. Fox, and M. P. Purohit, “Artificial intelligence-enabled healthcare delivery,” Jan. 01, 2019, *SAGE Publications Ltd*. doi: 10.1177/0141076818815510.
- [13] “Shining a light on medical technologies - MedTech Europe.” Accessed: Aug. 13, 2024. [Online]. Available: <https://www.medtecheurope.org/shining-a-light/>
- [14] J. E. Hollander and F. D. Sites, “The Transition from Reimagining to Recreating Health Care Is Now,” 2020, doi: 10.1056/CAT.20.0093.
- [15] “Ensuring the future of medical devices through cybersecurity measures - Medical Device Network.” Accessed: Aug. 14, 2024. [Online]. Available: <https://www.medicaldevice-network.com/analyst-comment/medical-devices-future-cybersecurity-measures/>
- [16] “Medical devices | European Medicines Agency.” Accessed: Jun. 25, 2024. [Online]. Available: <https://www.ema.europa.eu/en/human-regulatory-overview/medical-devices>
- [17] “FDA’s Role in Regulating Medical Devices | FDA.” Accessed: Jun. 25, 2024. [Online]. Available: <https://www.fda.gov/medical-devices/home-use-devices/fdas-role-regulating-medical-devices>
- [18] “O Infarmed - INFARMED, I.P.” Accessed: Apr. 24, 2024. [Online]. Available: <https://www.infarmed.pt/web/infarmed/apresentacao>

## Bibliography

- [19] “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.”
- [20] “EUROPA – European Commission – Growth – Regulatory policy - SMCS.” Accessed: Apr. 24, 2024. [Online]. Available: <https://webgate.ec.europa.eu/single-market-compliance-space/#/notified-bodies>
- [21] “International Medical Device Regulators Forum (IMDRF) | FDA.” Accessed: Jun. 26, 2024. [Online]. Available: <https://www.fda.gov/medical-devices/cdrh-international-affairs/international-medical-device-regulators-forum-imdrf>
- [22] “Q&A: Medical Devices Regulation.” Accessed: Apr. 03, 2024. [Online]. Available: [https://ec.europa.eu/commission/presscorner/detail/en/qanda\\_23\\_24](https://ec.europa.eu/commission/presscorner/detail/en/qanda_23_24)
- [23] C. Greco, “The Poly Implant Prothèse breast prostheses scandal: Embodied risk and social suffering,” *Soc Sci Med*, vol. 147, pp. 150–157, Dec. 2015, doi: 10.1016/j.socscimed.2015.10.068.
- [24] C. Heneghan, D. Langton, and M. Thompson, “Ongoing problems with metal-on-metal hip implants,” Mar. 03, 2012. doi: 10.1136/bmj.e1349.
- [25] R. A. Byrne, “Medical device regulation in Europe - what is changing and how can I become more involved?,” *EuroIntervention*, vol. 15, no. 8, pp. 647–649, Oct. 2019, doi: 10.4244/EIJV15I8A118.
- [26] “EUR-Lex - 12008E168 - EN,” *Official Journal* 115 , 09/05/2008 P. 0122 - 0124; .
- [27] “What’s changed compared to the MDD – The European Union Medical Device Regulation.” Accessed: Apr. 17, 2024. [Online]. Available: <https://eumdr.com/whats-changed/>
- [28] C. Kopp, “Product Life Cycle Explained: Stage and Examples.” Accessed: Aug. 17, 2024. [Online]. Available: <https://www.investopedia.com/terms/p/product-life-cycle.asp>
- [29] European Commission, “Is your software a Medical Device?”
- [30] “Medical device classification.” Accessed: Jun. 03, 2024. [Online]. Available: <https://webgate.ec.europa.eu/udi-helpdesk/en/other-relevant-information/medical-device-classification.html>
- [31] M. Gerhart, “MDR Classification Rule 11: The classification nightmare?” Accessed: Jul. 23, 2024. [Online]. Available: <https://blog.johner-institute.com/regulatory-affairs/mdr-rule-11/>
- [32] V. R. Sastri, “Process Validation for Medical Device Manufacturers and Their Suppliers,” in *Plastics in Medical Devices*, Elsevier, 2014, pp. 279–294. doi: 10.1016/b978-1-4557-3201-2.00011-2.
- [33] “EU Declaration of Conformity.” Accessed: Aug. 17, 2024. [Online]. Available: <https://www.johner-institute.com/articles/regulatory-affairs/and-more/eu-declaration-of-conformity/>
- [34] “Post-Market Surveillance in EU: Compliance and Success.” Accessed: Aug. 17, 2024. [Online]. Available: <https://www.eurodev.com/blog/post-market-surveillance-vigilance-on-the-european-market>
- [35] M. Monteiro, “Framework of Class I.” Accessed: Sep. 26, 2024. [Online]. Available: [https://drive.google.com/file/d/1\\_qGJrat6mGsoLwggZzp0EWHJh8lvxYqK/view?usp=sharing](https://drive.google.com/file/d/1_qGJrat6mGsoLwggZzp0EWHJh8lvxYqK/view?usp=sharing)
- [36] M. Monteiro, “Framework of Class IIa or higher .” Accessed: Sep. 26, 2024. [Online]. Available: [https://drive.google.com/file/d/1Zx\\_j8PcWY-HHjJa-5AioLc\\_t6WTt9k/view?usp=sharing](https://drive.google.com/file/d/1Zx_j8PcWY-HHjJa-5AioLc_t6WTt9k/view?usp=sharing)
- [37] IMDRF, “Software as a Medical Device: Possible Framework for Risk Categorization and Corresponding Considerations,” 2014.

## Bibliography

- [38] Medical Device Coordination Group, “Manual on borderline and classification for medical devices under Regulation (EU) 2017/745 on medical devices and Regulation (EU) 2017/746 on in vitro diagnostic medical devices,” 2022.
- [39] “TEAM-NB Position Paper New MDR Transition Timelines and Notified Body Capacity Structure,” 2023, Accessed: Apr. 10, 2024. [Online]. Available: <http://www.team-nb.org>
- [40] “Registo de DM e DIV - INFARMED, I.P.” Accessed: Apr. 10, 2024. [Online]. Available: <https://www.infarmed.pt/web/infarmed/entidades/dispositivos-medicos/registo-de-dm-e-div>
- [41] “Statement – We are on the cusp of a digital health revolution yet millions risk being left behind.” Accessed: Apr. 10, 2024. [Online]. Available: <https://www.who.int/europe/news/item/05-09-2023-statement---we-are-on-the-cusp-of-a-digital-health-revolution-yet-millions-risk-being-left-behind>
- [42] “Medical device software (MDSW) under EU MDR and IVDR.” Accessed: Apr. 10, 2024. [Online]. Available: <https://decomplx.com/medical-software-mdr/>
- [43] “Software as a Medical Device (SaaMD).” Accessed: Apr. 10, 2024. [Online]. Available: <https://www.eurodev.com/blog/medical-device-software-in-the-european-market>
- [44] U. J. Muehlematter, P. Daniore, and K. N. Vokinger, “Approval of artificial intelligence and machine learning-based medical devices in the USA and Europe (2015-20): a comparative analysis,” *Lancet Digit Health*, vol. 3, pp. e195–e203, 2021, doi: 10.1016/S2589-7500(20)30292-2.
- [45] “EUDAMED database - EUDAMED.” Accessed: Jun. 26, 2024. [Online]. Available: <https://ec.europa.eu/tools/eudamed/#/screen/home>

## Annex

Table 8.1. Medical device software risk categorization, according to MDCG 2019-11, Annex III.

			<b>Significance of Information</b>		
			<ul style="list-style-type: none"> <li>•Treat</li> <li>•Provide therapy to the human body</li> <li>•Diagnose disease/condition</li> <li>•Detect disease/condition</li> <li>•Screen disease/condition</li> </ul>	<ul style="list-style-type: none"> <li>•Aid in treatment</li> <li>•Provide enhanced support for safe and effective use of medicinal products or medical device</li> <li>•Aid to make a definitive diagnosis</li> <li>•Triage or identify early signs of a disease or condition</li> </ul>	<ul style="list-style-type: none"> <li>•Inform of options for:</li> <li>•Treatment</li> <li>•Diagnosis</li> <li>•Prevention</li> <li>•Aggregate relevant clinical information</li> </ul>
<b>Disease Type Patient Condition</b>	<b>Intervention Type</b>		<b>Treat or diagnose</b>	<b>Drive Clinical Management</b>	<b>Inform Clinical Management</b>
Life-treating	<ul style="list-style-type: none"> <li>• Requires major therapeutic interventions</li> <li>• Sometimes time critical</li> <li>• Accurate and timely diagnosis is vital to prevent death and public health risks.</li> </ul>	<b>Critical</b>	<b>Class III</b>	<b>Class IIb</b>	<b>Class IIa</b>
Moderate in progression. Often curable.	<ul style="list-style-type: none"> <li>•Does not require major therapeutic interventions</li> <li>•Not expected to be time-critical</li> <li>•Vital to avoiding unnecessary interventions</li> </ul>	<b>Serious</b>	<b>Class IIb</b>	<b>Class IIa</b>	<b>Class IIa</b>
Slow with the predictable progression of the disease state. Minor chronic illnesses or states. It may not be curable.	<ul style="list-style-type: none"> <li>•Can be managed effectively</li> </ul>	<b>Non serious</b>	<b>Class IIa</b>	<b>Class IIa</b>	<b>Class IIa</b>