

AI-Enabled Medical Devices: A Comprehensive Regulatory Review

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1 Introduction

Artificial intelligence (AI) is emerging as a transformative force in healthcare, with the potential to significantly enhance patient care, diagnosis, treatment, and overall health management. This promise of revolutionizing healthcare is supported by extensive academic and industrial advancements over the last decade, as shown by a six-fold increase in peer-reviewed publications² and the growing number of FDA-approved AI-enabled devices³.

Artificial intelligence (AI) encompasses a wide range of algorithms whose greatest benefit resides in their ability to learn from the real-world use and experience and its capability to improve its performance. These features make the technology unique and represent at the same time a fantastic regulatory challenge for its regulation; so far AI is apart from traditional regulated technologies. This hands-off approach presents several novel risks unique to AI technology, such as a lack of explainability or transparency, performance variations based on the quality of training data, the generation of biases and stereotypes, and competency gaps between developers lacking medical knowledge and clinicians with limited understanding of complex algorithms, as well as business professionals lacking expertise in both areas. A regulatory bottleneck whereby these AI based solutions offering unmet clinical needs must be pondered against the risk associated with its use and the safety of end user and patients.

The Food and Drug Administration (FDA) and its European counterpart have been issuing over the past 5 years a series of guidance documents and regulations to provide an adaptive regulatory framework to this iterative and ever evolving AI technology for the healthcare sector.

The objective of this paper is to present an overview of today's regulation. To do so, the path to the endorsed (EU) 2024/1986 will be firstly described and shortcoming compliance needs for the European market highlighted. The FDA's requirements will then be presented and gaps in today's regulatory standards underlined.

2 AI and EU

The European approach to AI risk management is characterized by a comprehensive range of legislations tailored to specific digital environments.

In 2019, the High-Level Expert Group on Artificial Intelligence (AI HLEG) published the first European guideline for managing AI. While acknowledging the potential socioeconomic benefits of AI, the "Ethics guidelines for trustworthy AI"⁴ emphasized the need for the technology to remain human-centric and that the new risk posed must be managed appropriately and proportionally. The document lays down the foundation for risk management in Europe for AI technology: Trustworthiness.

Trust in the development, deployment, and use of AI systems extends beyond the technology itself to encompass the socio-technical environments where AI applications operate. These guidelines establish essential requirements for ensuring trustworthy AI systems that are lawful, ethical, and robust (Table 1).

² [Artificial Intelligence in Healthcare: 2023 Year in Review \(medrxiv.org\)](#)

³ [Artificial Intelligence and Machine Learning \(AI/ML\)-Enabled Medical Devices | FDA](#)

⁴ [Ethics guidelines for trustworthy AI | Shaping Europe's digital future \(europa.eu\)](#)

Table 1: EU Key Requirements for a trustworthy AI

European Requirements	Associated systemic, individual and social aspect
Human agency and oversight	• Fundamental rights • Human agency • Human oversight
Technical robustness and safety	• Resilience to attack and security • Fall back plan • General safety, accuracy, reliability and reproducibility
Privacy and data governance	• Respect for privacy, quality and integrity of data, and access to data
Transparency	• Traceability • Explainability • Communication
Diversity, non-discrimination and fairness	• Avoidance of unfair bias • Accessibility and universal design • Stakeholder participation
Societal and environmental wellbeing	• Sustainability and environmental friendliness, social impact, society and democracy
Accountability	• Auditability • Minimisation and reporting of negative impact, trade-offs and redress.

While all requirements are of equal importance, context and potential tensions between them will need to be taken into account when applying them across different domains and industries. Implementation of these requirements should occur throughout the AI system's entire life cycle and depends on the specific application.

The EU's approach to AI risk management is complex and multifaceted, building on existing legislation such as the General Data Protection Regulation (GDPR), and spanning newly enacted legislation, i.e. the Digital Services Act⁵ and Digital Markets Act⁶ in 2022 and more recently the AI Act⁷.

2.1 Product Liability (default, causality)

In 2022, the European Commission published two directives, namely AI Liability Act (AILD)⁸ and AI Product Liability Act (PLD)⁹ to provide an harmonised product safety framework.

⁵ [REGULATION \(EU\) 2022/2065 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL](#) j

⁶ [REGULATION \(EU\) 2022/1925 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL](#) 5

⁷ [REGULATION \(EU\) 2024/1689 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL](#) j

⁸ [DIRECTIVE OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL](#)

⁹ [CJ24_AG\(2024\)758731_EN.docx \(live.com\)](#)

From the perspective of European legislation, liability is the means to address the fair allocation of risks inherent in modern technological products. Directive 85/374/CEE¹⁰ has provided, over the past 40 years, an effective tool for strict liability concerning defective goods within the European Union, including the 2017 European Regulations for medical¹¹ and in-vitro Diagnostic Devices¹².

The PLD, endorsed in March 2024 and set to come into force by March 2026, recognises software, such as operating systems, firmware, computer programs, applications or AI systems, as products. It extends the definition of defectiveness (article 7)¹³ to include “the effect on the product of its ability to continue to learn or acquire new features after it is placed on the market or put into service” making it particularly relevant to AI systems due to their ability to self-learn and acquire new capabilities. The PLD provisions include cybersecurity vulnerabilities as part of the assessment of product defectiveness, placing sole responsibility on the legal manufacturer, even when vulnerabilities are exploited by third parties. Interestingly, legal manufacturers are also liable for damage resulting from failures to provide software and/or security updates or upgrades in response to evolving cybersecurity risks. This framework undoubtedly creates additional pressure in Europe to release AI-enabled medical devices due to the recurrence of field safety notifications and product withdrawals stemming from software-related non-conforming products (Figure 1).

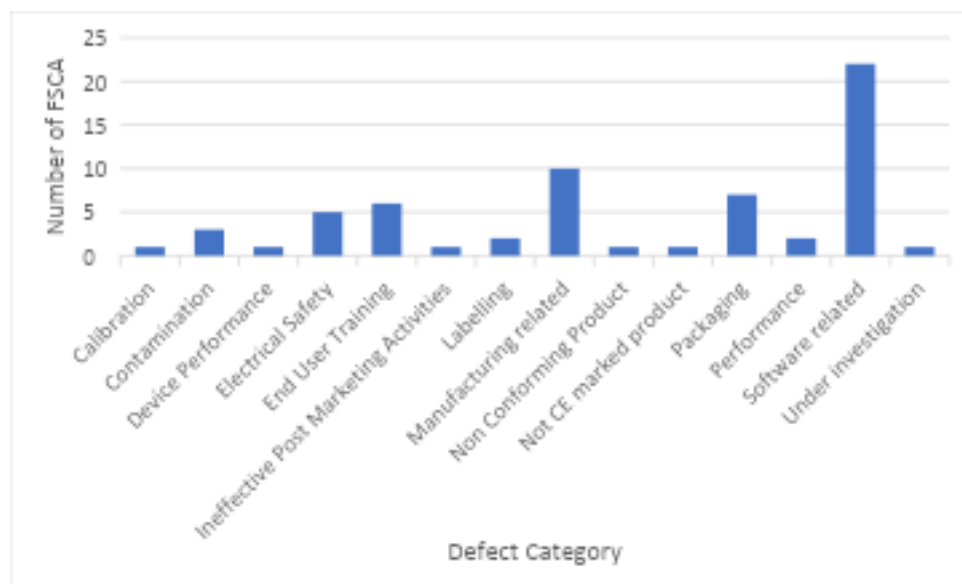


Figure 1: Distribution of Medical Device Malfunctions Categories reported to French National Agency for the Safety of Medicines and Health Products (ANSM) as part of Post Market Surveillance Studies for the period 01.08.2024 – 31.08.2024.

Published in parallel to the AI Product Liability Act, the AI Liability Act (AILD) restricts its scope to AI systems and relates to non-contractual fault-based claims for damage caused by either the output of an AI system

¹⁰ [Directive - 85/374 - EN - EUR-Lex \(europa.eu\)](https://eur-lex.europa.eu/eli/dir/1985/374/oj)

¹¹ (EU) 2017/745, article 10(16), [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 \(europa.eu\)](https://eur-lex.europa.eu/eli/reg/2017/745/oj)

¹² (EU)2017/746, article 10(15), [REGULATION \(EU\) 2017/ 746 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL - of 5 April 2017 - on in vitro diagnostic medical devices and repealing Directive 98/ 79/ EC and Commission Decision 2010/ 227/ EU \(europa.eu\)](https://eur-lex.europa.eu/eli/reg/2017/746/oj)

¹³ [Texts adopted - Liability for defective products - Tuesday, 12 March 2024 \(europa.eu\)](https://eur-lex.europa.eu/eli/reg/2024/1015/oj)

or the failure of an AI system to produce an output (Article 4). The AILD seeks to adapt, in general, national liability rules to the challenges posed by claims for damages caused by AI-enabled products and services¹⁴.

Both AILD and PLD constitute the final cornerstone of AI regulation in the EU. The liability proposals and the proposed EU AI Act are inherently intertwined: the latter does not contain any individual rights of affected persons, and the former lacks specific, substantive rules on AI development and deployment. Taken together, these acts may well trigger a “Brussels effect” in AI regulation, with significant consequences for the US and other countries¹⁵.

2.2 European Artificial Intelligence Act (AIA) comes into force

On the 1st of August 2024, the European EU Act, i.e. (EU)2024/1689, was endorsed with full applicability in 2026.

This risk-based regulation was voted after the liability framework to ensure that provisions are in place for those impacted by AI systems, allowing them to seek compensation when harms do occur.

The EU Artificial Intelligence Act is an important milestone in the field of AI, positioning the European Union at the forefront of AI regulation and innovation for the coming years. The act aims to harmonize rules for the development, market placement, use, and adoption of AI technology, while addressing the associated risks.

The AIA defines AI systems by including logic- or rule-based information processing (such as expert systems), as well as probabilistic algorithms (such as machine learning). It applies to all companies wishing to operate AI systems within the EU, irrespective of whether they’re based in the EU or not, alike the General Data Protection Regulation (GDPR)¹⁶

The objective of the AIA is to regulate AI systems and general-purpose AI models. Transversal in terms of applicable fields, Annex I of the act identifies harmonised legislations for which it is applicable, such as Regulation (EU) 2017/745 and Regulation (EU) 2017/746.

The AIA does have therefore major impact on the healthcare sector, where AI is already widely used for diagnostic purposes¹⁷, aid to clinical decision support¹⁸, classification and analysis of health data¹⁹,

¹⁴ Hacker P., Computer Law & Security Review, 51, 105871 (2024)

¹⁵ Arcilla B., Computer Law & Security Review, 54, 106012 (2024)

¹⁶ [REGULATION \(EU\) 2016/679 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL](#)

¹⁷ Al-Antari, M.A. Artificial Intelligence for Medical Diagnostics—Existing and Future AI Technology! Diagnostics 2023, 13, 688. <https://doi.org/10.3390/diagnostics13040688>

¹⁸ [Advancing clinical decision support: The role of artificial intelligence across six domains \(sciencedirectassets.com\)](#)

¹⁹ Arora, A., Alderman, J.E., Palmer, J. et al. The value of standards for health datasets in artificial intelligence-based applications. Nat Med 29, 2929–2938 (2023). <https://doi.org/10.1038/s41591-023-02608-w>

optimisation of medical therapy and treatment²⁰, as well as telemonitoring tool²¹, healthcare robots²², patient's wearable²³ or medical chatbots²⁴.

2.3 AIA, a risk based approach

The AIA, along with norms and regulations applicable to the medical device industry, follows a risk-based approach. Often qualified as “horizontal,” the AI Act implements a tiered system of regulatory obligations for a specifically enumerated list of AI applications. AI systems with unacceptable risk are those not meeting key requirements described in the previous section such as AI enabled manipulative technologies are prohibited on the EC market. However, a derogation has been made for law-enforced biometric identification in certain public spaces. Several AI applications, including deepfakes, chatbots, and biometric analysis, must clearly disclose their use to affected individuals.

AI risk classification ranges from prohibited, unacceptable risks—such as manipulative or social scoring AI—to high, transparency, and minimal risks (Figure 2). The higher the risk, the greater the scrutiny from the competent authority. The conformity assessment procedure for AI systems is determined by the risk associated with their intended purpose under normal conditions of use and foreseeable conditions of misuse.

Below the prohibited practice tier, high-risk AI systems must meet standards for data quality, accuracy, robustness, and non-discrimination, while also implementing technical documentation, record-keeping, risk management systems, and human oversight.

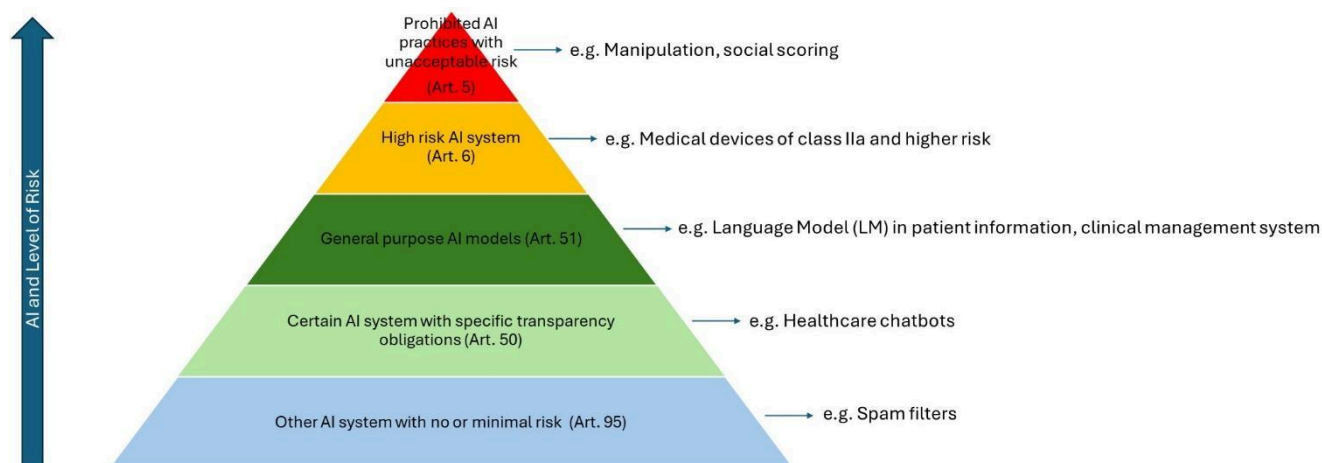


Figure 2: AIA risk-based approach.

²⁰ Derraz, B., Breda, G., Kaempfer, C. et al. New regulatory thinking is needed for AI-based personalised drug and cell therapies in precision oncology. *npj Precis. Onc.* 8, 23 (2024). <https://doi.org/10.1038/s41698-024-00517-w>

²¹ Kuziemycki C, Maeder AJ, John O, Gogia SB, Basu A, Meher S, Ito M. Role of Artificial Intelligence within the Telehealth Domain. *Yearb Med Inform.* 2019 Aug;28(1):35-40. doi: 10.1055/s-0039-1677897. Epub 2019 Apr 25. PMID: 31022750; PMCID: PMC6697552.

²² Kolpashchikov, D., Gerget, O., Meshcheryakov, R. (2024). Robotics and Artificial Intelligence in Healthcare. In: Lim, CP., Vaidya, A., Jain, N., Favorskaya, M.N., Jain, L.C. (eds) *Advances in Intelligent Healthcare Delivery and Management*. Intelligent Systems Reference Library, vol 258. Springer, Cham. https://doi.org/10.1007/978-3-031-65430-5_5

²³ Shajari, S.; Kuruvinareshetti, K.; Komeili, A.; Sundararaj, U. The Emergence of AI-Based Wearable Sensors for Digital Health Technology: A Review. *Sensors* **2023**, *23*, 9498. <https://doi.org/10.3390/s23239498>

²⁴ Xu L, Sanders L, Li K, Chow JCL. Chatbot for Health Care and Oncology Applications Using Artificial Intelligence and Machine Learning: Systematic Review. *JMIR Cancer.* 2021 Nov 29;7(4):e27850. doi: 10.2196/27850. PMID: 34847056; PMCID: PMC8669585.

Annex III of the AI Act lists high-risk AI systems as those meeting the definition provided in Article 6(2). Due to the dynamic nature of AI innovation, AI systems not listed at the time the Act came into force shall be considered high-risk if both of the following conditions are met:

- a) The AI system is intended to be used as a safety component of a product, or the AI system itself is a product, covered by the Union harmonization legislation listed in Annex I;
- b) The product whose safety component is the AI system, or the AI system itself as a product, is required to undergo a third-party conformity assessment before being placed on the market or put into service, pursuant to the Union harmonization legislation listed in Annex I.

This applies to medical devices of class IIa and higher classifications used for the following medical purposes: diagnosis, prevention, prediction, prognosis, treatment, and alleviation of disease, injury, or disability, when using AI. Following the exemption attributed to population scoring, AI systems used to evaluate and classify emergency calls or dispatch emergency first responders are considered high-risk.

General-purpose AI models are an interesting category of AI systems, as they can fall into either the high- or low-risk category depending on the systemic risk they may pose to targeted users or populations. Article 3(63) defines a general-purpose AI model as one that:

- Is trained with a large amount of data using self-supervision at scale;
- Displays significant generality and is capable of competently performing a wide range of distinct tasks, regardless of how the model is placed on the market;
- Can be integrated into a variety of downstream systems or applications, except for AI models used for research, development, or prototyping activities before they are placed on the market.

In addition to meeting the general obligations outlined in Article 53, compliance of such systems with the (EU) 2024/1689 regulation can be demonstrated either through internal control, as outlined in Annex VI, or through the assessment of the legal manufacturer's quality management system and the device's technical documentation (Annex VII). Table 2 provides an overview of the two compliance routes.

Table 2: oversight of low-risk AI system.

Route A: Internal Control requirements (Annex VI)	Route B: QMS and TD requirements (Annex VII)
• A risk management system • A post marketing monitoring system • Procedure for reporting serious incidents • Communication with regulatory stakeholders • Resource management incl. measures for the security of supply • Identified management responsibilities	• An auditable quality management system meeting relevant harmonised regulation requirements • A controlled technical documentation as described in Annexes IV and XI as well as essential requirements reported in articles 8-15 • A risk management system • Training, validation and testing data sets shall be relevant, sufficiently representative, and to the best extent possible, free from errors and complete in view of the intended purpose • A technical documentation compliant with the requirement of Annex IV

As soon as these general-purpose AI systems are associated with a “systemic risk”, as defined by Art.3(65), requirements regarding risk management, data and their governance, record keeping, transparency, human oversight, as well as those for accuracy, robustness and cybersecurity and technical documentation are more stringent, such as those for post marketing and design control activities. Obligations of providers of high risk AI system is documented in Article 16 and are also required to:

- Register into European database (Art. 71) providing the information described in Annexes VIII-IX
- Testing requirements (Article 60) providing the information described in Annex IX

Table 3: Illustrative representation of regulatory requirements between low and high class AI system

	Low risk AI system	High Risk AI system
QMS	Article 17 1(g-m)	Article 17
Record Keeping	N/A	Article 12
Risk Management	Article 9(7)	Article 9
Data and data governance	Article 10(3,4)	Article 10
Technical Documentation	Annex IV	Article 11 Annex IV
Transparency and provision of information to deployers	Article 13 (3a)	Article 13
Human oversight	N/A	Article 14
Accuracy, robustness and cybersecurity	N/A	Article 15

Table 4 Example of AI technologies and their risk classification²⁵

High Risk	Limited Risk	Minimal or No risk
- Critical infrastructures (e.g. transport), that could put the life and health of citizens at risk - Educational or vocational training, that may determine the access to education and professional course of someone's life (e.g. scoring of exams) - Safety components of products (e.g. AI application in robot-assisted surgery) - Employment, management of workers and access to self-employment (e.g. CV-sorting software for recruitment procedures) - Administration of justice and democratic processes (e.g. AI solutions to search for court rulings)	Risks associated with lack of transparency in AI usage. Practically, human should be made aware when they interact a machine (e.g. a chatbot). AI generated content, i.e. text, audio and video should be labelled as artificially generated	This includes applications such as AI-enabled video games or spam filters

It is worth noting that the AI Act distinguishes between AI systems (Art. 3(1)) and General-Purpose AI models and their systems, as defined in Art. 3(63) and Art. 3(66), respectively, to differentiate their particular obligations and responsibilities.

In addition to establishing state-of-the-art codes of practice similar to the International Medical Device Regulator Forum (IMDRF), an AI Office has been created to enforce the rules for general-purpose AI models. This is supported by the powers granted to the Commission under the AI Act, including the ability to evaluate general-purpose AI models, request information and actions from model providers, and apply sanctions as outlined in (EU) 2024/1689 Recital 116. AI systems are supervised by national market surveillance authorities.

The AIA is not fully inclusive in terms of AI technologies. Specifically, AI systems intended solely for research and development, as well as free and open-source systems, are outside the scope of the Act (Art. 2 (6,10)), unless they are placed on the market or put into service as high-risk, or if they are subject to transparency obligations when interacting directly with individuals (Art. 2 (12)).

²⁵ [AI Act](#)

2.4 AIA, next steps

The AI act will be fully applicable by August 2026 as per Art. 113. Nevertheless, some exemptions apply as per table 5.

Table 5: Implementation Guidelines

(EU) 2024/1689	Date of Application
Chapter I, General Provisions Chapter II, Prohibited Practices	2025.02.02
Chapter III Section 4, Notifying authorities and notified bodies Chapter V, General Purpose AI Models Chapter VII, Governance Chapter XII, Penalties Article 78, Confidentiality	2025.08.02
Article 6(1), Classification rules for high-risk AI systems	2027.08.02

This timeline marks a turning point in the regulatory oversight of AI system in the EU, particularly for the healthcare sector, where the use of AI products for diagnosis, treatment, and patient care is rapidly growing.

3 FDA and AI

In the USA, “the Food and Drug Administration (FDA) is responsible for protecting the public health by assuring the safety, efficacy, and security of human and veterinary drugs, biological products, medical devices, our nation's food supply, cosmetics, and products that emit radiation”²⁶. The American national regulator has also been under pressure to balance the regulatory paradigm of, on one hand, facilitating innovation, and on the other, ensuring that safe and effective technology reaches users, including patients and healthcare professionals.

AI enabled technologies have been impetus behind recent regulatory development. In 2019, the FDA published its first discussion paper on Artificial Intelligence and Machine Learning²⁷ acknowledging that traditional paradigm of medical device regulation was not designed for adaptive AI/ML technologies. Therefore, tailored regulation is necessary to ensure the safety and effectiveness of AI/ML-based software as a medical device (SaMD).

Different from the mechanistic European approach to AI enabled medical devices, the action plan published in 2021²⁸ proposes a regulatory framework for AI/ML based SaMD including for the predetermined change control plan. Indeed, the SaMD Pre specifications (SPS) describe “what” aspects the manufacturer intends to change through learning and the algorithm Change Protocol (ACP) explains “how” the algorithm will learn and change while remaining safe and effective. As such, Good Machine Learning Practice (GMLP)²⁹ for medical development was released to define the 10 guiding principles to address the unique nature of such

²⁶[Food and Drug Administration \(FDA\)](#)

²⁷[Proposed Regulatory Framework for Modification of Artificial Intelligence/Machine Learning \(AI-ML\)-Based Software as Medical Device \(SaMD\) Discussion Paper and Request for Feedback](#)

²⁸[Artificial Intelligence/Machine Learning \(AI/ML\)-Based Software as a Medical Device \(SaMD\) Action Plan. 2021](#)

²⁹[Good Machine Learning Practice for Medical Device Development: Guiding Principles. 2021](#)

products. The guiding principles of Predetermined Change Control Plans for Medical Device were drafted 2023³⁰, followed more recently by a draft Guidance Document for Industry and FDA Staff (2024)³¹.

In addition to encouraging harmonization through a set of best practices, the Action Plan also aims to capture the FDA's commitment to (1) supporting a patient-centered approach that incorporates transparency in usage and (2) supporting the development of regulatory science methods to evaluate and address algorithmic bias, promoting algorithm robustness. This approach aligns with European regulation in terms of a human-centered framework while ensuring that trustworthy, robust, and accurate AI-SaMD reaches the market. Table 6 provides a summary of AI/ML Medical Device Regulatory Policy and Guidance from 2019-2024.

Table 6: AI/ML Medical Deice Regulatory Policy and Guidance 2019-2024

Regulatory Development	Year
Proposed Regulatory Framework for Modifications to Artificial Intelligence/Machine Learning (AI/ML)-Based Software as a Medical Device (SaMD)—Discussion Paper and Request for Feedback	2019
Artificial Intelligence/Machine Learning (AI/ML)-Based Software as a Medical Device (SaMD) Action Plan	2021
Good Machine Learning Practice for Medical Device Development: Guiding Principles	2021
Marketing Submission Recommendation for a Predetermined Change Control Plan for Artificial Intelligence / Machine Learning (AI/ML) Enabled Device Software Function	2023
Predetermined Change Control Plans for Machine Learning-Enabled Medical Devices: Guiding Principles	2023
Artificial Intelligence and Machine Learning (AI/ML)-Enabled Medical Devices	2024
Predetermined Change Control Plans for Medical Devices Draft Guidance for Industry and FDA Staff	2024

Although many communities have published their interpretations of FDA's expectations for device approval, the most comprehensive checklist available is the one published by Focus Group on Artificial Intelligence for Health (FG-AI4H)³². This technical report provides a step-by-step approach for the implementation of safe and effective AI-ML based medical devices.

3.1 SaMD and Risk Categorisation

The IMDRF SaMD risk categorization framework takes a risk-based approach to categorize SaMD based on intended use, similar to traditional risk-based approaches used by the FDA. The IMDRF risk framework³³ and more recently the FDA's Global Approach to Software as a Medical Device (33)³⁴ identify the following two major factors as providing a description of the intended use of the SaMD:

- Significance of information provided by the SaMD to the healthcare decision

³⁰ [Predetermined Change Control Plans for Machine Learning-Enabled Medical Devices: Guiding Principles. 2023](#)

³¹ [Predetermined Change Control Plans for Medical Devices Draft Guidance for Industry and FDA Staff. 2024](#)

³² [Good practices for health applications of machine learning: Considerations for manufacturers and regulators. 2022](#)

³³ ["Software as a Medical Device": Possible Framework for Risk Categorization and Corresponding Considerations. 2014](#)

³⁴ [Global Approach to Software as a Medical Device. 2022](#)

- State of healthcare situation or condition

These factors describing the intended use can be used for AI/ML-based SaMD risk classification.

Table 7: SaMD Risk Categorisation

Tate of Healthcare situation or condition	Significance of information provided by SaMD to health care decision		
	Treat or diagnose	Drive clinical management	Inform clinical management
Critical	IV	III	II
Serious	III	II	I
Non-serious	II	I	I

3.2 Initial 510(k) or PMA submission for an AI/ML-enabled device

In the US, device risk categorization determines the FDA's requirements for application submission. A 510(k) submission is used for medium-risk medical devices (usually Class II) that are substantially equivalent to an already marketed device, making it ideal for modifications to existing devices or for new devices similar to existing ones. A PMA (Pre-Market Approval) application is required for high-risk medical devices (Class III), such as those that support or sustain human life or pose a potential risk of illness or injury. Extensive evidence of safety and effectiveness, typically including clinical trials, is necessary for PMA applications. Nevertheless, the data submitted to the FDA for AI/ML SaMD requires additional information to meet guidance requirements, including:

- Data management, such as data collection, data quality, data storage, bias monitoring, data annotation, pre-processing, and version control.
- Model development, including model preparation, training, evaluation, documentation, and validation.
- Clinical validation.
- Post-market surveillance and measures for continuous learning systems.
- Adherence to the predetermined change control plan for medical devices, specifically for continuous learning systems (as opposed to locked algorithms).

Note that as described in a 2021 discussion paper³⁵, regulatory review is mandatory if changes impact performance (analytical and clinical performance), input data type, and intended use of the medical device. Software modifications may affect any of these three aspects, so an analysis and justification should be provided regarding the extent of the impact on them. The third guiding principle of Good Machine Learning Practices (GMLPs) states that "data collection protocols should ensure that the relevant characteristics of the intended patient population (for example, in terms of age, gender, sex, race, and ethnicity), use, and measurement inputs are sufficiently represented in a sample of adequate size in the clinical study and training and test datasets so that results can be reasonably generalized to the population of interest." This is important to managing bias, promoting appropriate and generalizable performance across the intended patient population, assessing usability, and identifying circumstances where the model may underperform.

³⁵ [Proposed Regulatory Framework for Modifications to Artificial Intelligence / Machine Learning \(AI/ML\) Based software as Medical Device \(SaMD\). Discussion Paper and Request for Feedback. \(2021\)](#)

The principles of change management, risk management, post-market real-world data, and documentation are key in assessing changes to the product throughout its total product lifecycle (TPLC). If changes do not impact the three parameters upon risk evaluation, the decision should be confirmed through successful, routine verification and validation activities, as per FDA guidelines.

As discussed earlier, the core philosophy regarding the type of data required specifically for AI systems is based on ethical principles, including transparency and explainability, robustness, real-world performance, autonomy, accountability, and privacy.

4 Guidance and Standards

Alike regulatory authorities, the rapid development of AI system forced standard development organisations to develop standards based on best practices and inputs from panel experts.

The International Standard Organisation (ISO) and the International Electrotechnical Commission (IEC) have been highly active in developing international standards for AI/ML. At the time of this publication, 31 ISO standards have been published and another 36 are under development ³⁶.

The Association for the Advancement of Medical Instrumentation (AAMI) published BS/AAMI 34971:2023³⁷, Application of ISO 14971 to machine learning in artificial intelligence — Guide. This guidance document applies the standard risk management process to the elevated or unique safety-related vulnerabilities and risks of AI- and ML-enabled medical devices, including:

- Data management
- Bias
- Data storage, security, and privacy
- Overtrust
- Adaptive systems

5 Concluding Remarks

Regulatory development in the AI space have largely occurred in North America and the EU. While both the FDA and the EC have developed harmonized principles, global harmonization remains lacking. Both apply a risk-based approach for AI/ML enabled medical devices, with the difference of FDA being more medical device specific and EU integrating an “horizontal” AI Act that interlinks with sector specific medical device and in-vitro diagnostic device regulations.

As acknowledged by the article 56 of the (EU) 2024/1689, the regulators give them time to adapt their current requirements to the ever-evolving AI and therefore introduce a regulatory uncertainty that medical device manufacturer must consider when developing or maintaining their product on the market.

5.1 How to be prepared to comply with EU AI Act?

1. Compile an inventory of your AI systems/models and assess whether they fall within the scope of the EU AI Act
2. Classify your AI systems/models
3. Identify your role for each AI system/model
4. Map your obligations for each AI system/model
5. Identify any regulatory overlaps
6. Prepare an inventory of existing documentation and processes, then conduct a gap analysis

³⁶ [ISO/IEC JTC 1/SC 42 Artificial intelligence. \(2024.09.26\).](#)

³⁷ [BS/AAMI 34971:2023 | 31 May 2023 | BSI Knowledge \(bsigroup.com\)](#)

7. Identify your internal resources and needs
8. Prepare a roadmap and assign responsibilities
9. Monitor regulatory developments
10. Get involved in regulatory sandboxes, codes of practice, codes of conduct & standardization.