Regulations and Directives—Past, Present, Future

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Abstract Throughout the past few decades, there has been a considerable evolution in the regulation of medical devices, with modifications made to maintain patient safety and enhance device functionality. Medical device regulation used to be less strict, and many devices were certified without going through rigorous testing. This raised various safety issues, and a series of high-profile incidents demonstrated the necessity for more stringent regulation. In order to address this problem, regulators from all over the world established guidelines and laws requiring manufacturers to give proof of the safety and effectiveness of their devices. The Medical Devices Directive (MDD), enacted in Europe in 1993, established the legal foundation for medical device regulation within the European Union. The Medical Device Amendments of 1976 were introduced in the United States of America. Currently, medical device regulation is more comprehensive, with more rigorous testing and evaluation procedures in place. In the US, the Food and Drug Administration (FDA) oversees the regulation of medical devices, and requires manufacturers to provide evidence of safety and efficacy before a device can be approved for use. In Europe, the MDD has been replaced by the Medical Device Regulation (MDR) and the In Vitro Diagnostic Regulation (IVDR), which impose stricter requirements on medical device manufacturers, distributors, and importers. In other parts of the world, medical device regulation is also becoming more stringent. Medical device legislation is probably going to keep changing in the future. The use of real-world evidence (RWE) to guide regulatory choices is receiving more attention, and this trend is likely to continue. With the provision of a more thorough understanding of how devices function in the actual world, the usage of RWE can aid in enhancing the accuracy of regulatory decisions. The usage of digital health technology, such as wearables and smartphone apps, is also gaining popularity. Healthcare could be transformed by these technologies, but they also present new regulatory difficulties. As a result, regulatory organisations all

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around the world are investigating fresh ideas for regulating digital health technologies. Globally, the past, present and future of medical device regulation show how critical it is to protect patient safety and improve device functionality. Although the regulations have tightened over time, they still need to adapt and change to meet the demands of the ever-changing healthcare environment, which presents challenges not only for the manufacturers themselves but also for the competent bodies that carry out the conformity assessment of the products in question.

1 Introduction

Health has always been, is and will always be the most important thing that for sure should be taken care of. Even with all technological development of modern society, there are still a lot of challenges in maintaining the health of the population worldwide. Development of medical devices have dramatically changed the way medical care is provided to patients.

The previous edition of the book Inspection of Medical Devices provided valuable insights into how the development of medical devices has revolutionised healthcare delivery, highlighting the importance of maintaining health and addressing the challenges that come with it [1]. Various regulatory bodies provide definitions of the term medical device, such as US Food and Drug Administration (FDA), World Health Organisation (WHO), and European Commission, which gives the most comprehensive one. According to the European Commission, a medical device is defined as "*any instrument, apparatus, appliance, software, material or other article, whether used alone or in combination, including the software intended by its manufacturer to be used specifically for diagnostic and/or therapeutic purposes*". Since medical devices include a variety of types and models and given the fact that they have direct impact on health, these devices are under strict control worldwide. Their safety and performance characteristics are subject to strict conformity assessments also to ensure the quality and reliability of diagnosis and treatment.

To define appropriate regulations and quality assessment for medical devices, firstly the classification system needs to be defined. Medical devices are usually divided into different groups or classes. The differentiation into classes can vary from country to country. Some countries have a medical device classification system consisting of the following categories: general medical devices, active implantable medical devices (AIMD) and in vitro diagnostic devices (IVD). This system is adopted in Europe and many other countries in the world, while in very few countries these products are categorised into the same group. More specifically, all medical devices are classified based on the risk. In the European Union (EU) general medical devices are classified as class I, class I sterile, class I measuring, class IIa, class IIb or class III where class III devices represent the highest risk. Active implantable medical devices are not classified and in vitro diagnostic devices have their own classification system. The previous edition also provided information on the classification of medical devices in the United States as Class I (general controls), II (special

controls), or III (premarket approval), where Class III devices pose the greatest risk and require greater control. In Europe medical devices are divided into three different groups; active implantable medical devices (AIMD), general medical devices and in vitro diagnostic devices (IVD).

Observed worldwide, the classification doesn't differ very much between countries. The main difference is the way medical devices are regulated. Some countries issue regulations covering all groups of medical devices, and others define regulations for each class separately. Also, in some countries they are regulated as drugs, while in other countries they are regulated by special regulations. The variety and differences in medical device regulations present in countries are creating obstacles for the medical device market. In order for a manufacturer to introduce a new medical device to the market it must comply with a variety of regulations depending on the country in which this device will be sold. In the end, this affects the quality of care provided to patients because in this way some new medical devices become unavailable in certain countries due to specific regulations.

The directives and regulations outline every step of medical device development, including ideation, design, and development phases, as well as testing, approval, and certification prior to manufacturing, the actual production process, and post-market surveillance. In the European Union, Medical Device Directives were replaced by Medical Device Regulation in 2020. In the United States of America, the FDA is regulating all aspects of medical device regulation. In other regions and countries of the world, the area of medical devices is under strict control and supervision. A large number of countries outside the Europe base their legislation in the area of medical devices on EU legislation. Other countries in the world have adopted a similar regulatory framework for medical devices, as it has been mentioned above for the EU and USA. In all regions, the manufacturer governs the overall process from ideation to market, whereas independent third parties give approval and certification before placing the device on the market.

2 EU Legislation

EU legislation is divided into two levels with primary legislation embodied by the treaties, and secondary legislation given in the form of regulations, directives and decisions which are used to implement the policies set out within the treaties [2]. Secondary legislation is made by the EU institutions. It is the third major source of Community law after the treaties (primary legislation) and international agreements. It comprises:

- binding legal instruments (regulations, directives and decisions)
- non-binding instruments (resolutions, opinions).

In order to increase safety in the production of industrial products, manufacturers have to follow the relevant legislation. This legislation in the EU is given through the directives and regulations followed by appropriate harmonised standards set out in

the directives and regulation. In addition to the stated documentation, there are also other acts of European Union Law. Legislation serves us primarily to protect citizens. It means the end consumers from low-quality products that do not comply with the minimum requirements related to the safety of products intended to be released on the market of a country. These requirements are precisely stated through directives and regulations if it is EU regulations or some other type of regulations in other countries of the world with regulated markets.

The description and meaning of legal acts in accordance with EU law is given bellow [3, 4]:

- A "**regulation**" is a binding legislative act. It must be applied in its entirety across the EU.
- A "**directive**" is a legislative act that sets out a goal that all EU countries must achieve. However, it is up to the individual countries to devise their own laws on how to reach these goals.
- A "**decision**" is binding on those to whom it is addressed (e.g. an EU country or an individual company) and is directly applicable.
- A "**recommendation**" is not binding. When the Commission issued a recommendation that EU countries' law authorities improve their use of videoconferencing to help judicial services work better across borders, this did not have any legal consequences. A recommendation allows the institutions to make their views known and to suggest a line of action without imposing any legal obligation on those to whom it is addressed.
- An "**opinion**" is an instrument that allows the institutions to make a statement in a non-binding fashion, in other words without imposing any legal obligation on those to whom it is addressed. An opinion is not binding. It can be issued by the main EU institutions (Commission, Council, Parliament), the Committee of the Regions and the European Economic and Social Committee. While laws are being made, the committees give opinions from their specific regional or economic and social viewpoint.

Review of EU legislation can be made via the official website of the EU which is especially dedicated to this issue. An integral part of the directives are harmonised standards. A **harmonised standard** [5] is a European standard developed by one of the recognised European Standards Organisation: CEN [6], CENELEC [7], or ETSI [8]. It was created following a request from the European Commission to one of these organisations. Manufacturers, other economic operators, or conformity assessment bodies can use harmonised standards to demonstrate that products, services, or processes comply with relevant EU legislation. The references of harmonised standards must be published in the Official Journal of the European Union. The purpose of this website is to provide access to the latest lists of references of harmonised standards and other European standards published in the Official Journal of the European Union (OJEU).

EUR-Lex provides free access to EU law and other documents considered to be public. The content on the official website is available in 24 official languages of the European Union. This chapter has the purpose to describe the legislation used

in the EU in the field of industrial products, and the approaches to be followed by producers (manufacturer) of those products in order to be approved and placed in the EU market.

3 Placing of Products in the Market of EU in Accordance with EU Legislation

Only products that meet all applicable requirements can be released on the EU market. The conformity assessment procedure is carried out before the actual release of the product on the market, i.e. before the product in question can be put on sale. Before placing a product in the market, implying that it is ready for use, the product has to be approved by a competing body providing conformity assessment of a tested subject with appropriate reference. There are different recognized approaches in the process of approval.

Industrial products must comply with the rules established by EU legislation, either by Directive or Regulation related to specific products prior to being put in the market and/or put into service in the EU, the European Economic Area, or Switzerland. All industrial products intended for the EU market must bear CE mark, which represents the conformity assessment with relevant legislation. In addition to this mark, certain industrial products must be marked with some other marks, such as the requirement in the field of measuring instruments and non-automatic weighing instruments, which refers to a supplementary metrology marking. The CE marking and the supplementary metrology marking shall be affixed before the measuring instrument is placed on the market. The supplementary metrology marking shall consist of the capital letter 'M' and the last two digits of the year of its affixing, surrounded by a rectangle. CE marking and the supplementary metrology marking are accompanied by the EU declaration of conformity which gives us brief insight in legislation and harmonised standards used in production of the subject product and its conformity with these documents [9]. Since the United Kingdom left the European Union, they have also introduced a new conformity mark. The UKCA (UK Conformity Assessment) mark is the new UK product marking that will be required for certain products being placed on the market in Great Britain (England, Wales and Scotland). It covers most products that previously required the CE mark (measuring instruments, medical devices, etc.).

It will not be recognized in the EU market. Products that require CE marking will still need a CE marking to be sold in the EU [10]. In the field of medical devices, whether they are produced for the EU or American market, the manufacturer is obliged to place a Unique Device Identification (UDI) on the product itself or the packaging. The unique device identification is a unique numeric or alphanumeric code related to a medical device. It allows for a clear and unambiguous identification of specific devices on the market and facilitates their traceability [11].

4 EU Legislation in the Field of Medical Devices

One of the legislation aligned with the New Legislative framework is Regulation 2017/745/EU on medical devices. Medical devices require special attention because they are directly related to health, which represents one of the categories of legal metrology, as described in paragraph 7. (Medicine in the field of Legal Metrology). First of all, it is necessary to clarify what a medical device represents. In accordance with regulation 2017/745/EU, medical device has the following meaning: *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.*

Legislation in the field of medicine in the European Union, i.e. legislation relating to medical devices, is based on Regulation (EU) 2017/745 of 5 April 2017 [12]. This regulation further relies on the following directives:

- Directive **93/68/EEC** (CE Marking);
- Directive Regulation (EU) 2017/746 on in vitro diagnostic medical devices.;
- Regulation (EU) 2020/561 of the European Parliament and of the Council of 23 April 2020 amending Regulation (EU) 2017/745 on medical devices

In the past, one more directives were in force, but they have been repealed with legal acts mentioned above. As mentioned in the introduction, beside legislation on medical devices, there are a great number of written standards used in manufacturing of medical devices. Changes in legislation are not very frequent and if, they are mostly related to technological changes in the specific products which they apply to. Directives are replaced by amending or adding new requirements and are assigned with a new codification. For example, in the field of measuring instruments, the currently valid directive from 2014 bears the codification 2014/32/EU, and the earlier directive on measuring instruments from 2009 bore the designation 2009/34/EC. From the codification itself, it is possible to state that the period that passed between the last two editions of the directive on measuring instruments was 5 years.

This is not the same in a case of medical devices. This is a very important area from the point of view of risk for user and treatment of patients, and currently in this

area in force is regulation (EU) 2017/745 (from 2017), which replaced directive 93/442/EEC from 1992. When it comes to medical devices it is possible to conclude, the earlier act, which was a directive, was replaced by a regulation in 2017, which rarely happens, and this further indicates how important this area is and how this harmonised act has become a binding legislative act in all EU countries. Although a long period has passed since the publication of the directive from 1993 until its replacement by the regulation in 2017, this does not mean that there have been no changes since 1993. The directive from 1993 was revised several times, but it contained the same codification during the 29 years it was in force (it ceased to be valid on 05/25/2021 due to the transition period to (EU) 2017/745). In order to improve the internal market for goods and strengthen the conditions for placing a wide range of products on the EU market, in 2008 the New Legislative Framework (NLF) was adopted. The NLF represents the set of measures that aim to improve market surveillance and boost the quality of conformity assessments. In the past it was recognised by New Approach, which was a regulatory technique used for removing technical barriers to trade in Europe. The NLF which is closely related to New Approach, consist of following legislation:

- Regulation (EC) 765/2008 Search for available translations of the preceding setting out the requirements for accreditation and the market surveillance of products
- Decision 768/2008 Search for available translations of the preceding on a common framework for the marketing of products, which includes reference provisions to incorporate in product legislation revisions. In effect, it is a template for future product harmonisation legislation
- Regulation (EU) 2019/1020 Search for available translations of the preceding on market surveillance and compliance of products.

The NLF improves market surveillance, sets clear and transparent rules for accreditation of conformity assessment bodies, boosts the quality of and confidence in the conformity assessment of products clarifies the meaning of CE marking and establishes a common legal framework for industrial products in the form of a toolbox of measures for use in future legislation. Number of legislation which is currently covered by NLF is 24 different directives, regulations and delegated acts, covering the fields like measuring instruments, electromagnetic compatibility, medical devices, Radio equipment and industry fields where product safety is very important, etc. In relation to the conformity assessment the manufacturer has certain responsibilities, reflected depending on the applied procedures. The manufacturer must take all necessary measures to ensure that the production process satisfy conformity of the product in order to set the CE mark on the product, which includes drawing technical documentation and creating EC[1] declaration of conformity. It is very important that the

[1] As part of conformity assessment, the manufacturer or the authorised representative must draw up a Declaration of conformity (DoC). The declaration should contain all information to identify:
- the product.
- the legislation according to which it is issued.

product is accompanied by a product declaration of conformity that provides information about the product in question, which is the obligation of the manufacturer or his authorised representative if the manufacturer is not from the EU. The declaration itself must contain information indicating the essential elements of the product in question and compliance with the relevant regulations, directives and harmonised standards.

Depending on the legislation, it is possible to claim from the manufacturer to submit products for testing and certification by a third party (usually a notified body) or to certify quality systems by a notified body.

5 Notified Bodies for Conformity Assessment

A notified body is an organisation designated by an EU country to assess the conformity of certain products before being placed on the market. These bodies carry out tasks related to conformity assessment procedures set out in the applicable legislation, when a third party is required. The European Commission publishes a list of such notified bodies [13].

Notified bodies must fulfil requirements prescribed by certain legislation. This mainly refers to the confirmation of the competences by a third party, an accredited body in accordance with some of the required standards for conformity assessment or through peer review by peers (e.g. the area of measuring instruments). Bodies performing conformity assessment shall be accredited by the national accreditation body for specified standards. Accreditation implies confirmation of competences of the third party to an authority that may perform conformity assessment, respectively conformity with the requirements of applicable standards and additional requirements for the subject matter. For example, for the area of measuring instruments, notified bodies must be accredited or peer reviewed in accordance with the standards of the ISO 17000 family, depending on the module of conformity assessment (described in paragraph 5. Conformity assessment of industrial products), such as, for example:

- EN ISO/IEC 17020- Conformity assessment — Requirements for the operation of various types of bodies performing inspection
- EN ISO/IEC 17021- Conformity assessment — Requirements for bodies providing audit and certification of management systems
- EN ISO/IEC 17025—General requirements for the competence of testing and calibration laboratories
- EN ISO/IEC 17065- Conformity assessment — Requirements for bodies certifying products, processes and services.

• the manufacturer or the authorised representative.
• the notified body if applicable.
• a reference to harmonised standards or other normative documents, where appropriate.

Setting out the requirements for accreditation and market surveillance relating to the marketing of products is done by Regulation 765/2008/EC [14], which should be seen as a complementary to Decision 768/2008/EC (on a common framework for the marketing of products). Accreditation provides authoritative statements about technical competence of bodies whose task is to ensure conformity with the applicable requirements.

The situation is different in the field of medical devices, where notified bodies do not have to be accredited, but are subject to even stricter requirements as prescribed by Regulation 2017/745(EU) also known by its abbreviation MDR. The MDR expands the powers of notified bodies with regard to post-market clinical surveillance (e.g. unannounced audits, spot checks and product reviews). In accordance with the MDR any EU Member State that intends to designate a conformity assessment body as a notified body, or has designated a notified body, to carry out conformity assessment activities under the MDR shall appoint an authority for notified bodies, which may consist of separate constituent entities under national law and shall be responsible for setting up and carrying out the necessary procedures for the assessment, designation and notification of conformity assessment bodies and for the monitoring of notified bodies, including subcontractors and subsidiaries of those bodies. Where the authority responsible for notified bodies is a different authority from the national competent authority for medical devices, it shall ensure that the national authority responsible for medical devices is consulted on relevant matters.

In the phase of the production, Medical devices are subject to compliance with certain legislation and harmonised standards. Currently, in Europe, the applied EU Legislation for the production of measuring devices are Directive 93/42/EEC (notified bodies designated under Directive 93/42/EEC as listed here are no longer able to issue new certificates under that Directive, but only allowed to carry out surveillance activities for certificates validly issued under that Directive in the transitional period) and Regulation 2017/745/EU. The greatest responsibility in the production of medical devices holds the manufacturer himself, who has to ensure that the product meets the applicable legal requirements and, on the other hand, there is a notified body for conducting conformity assessment appointed by EU governments and with the obligation to validate and ensure that the product fulfil all the relevant requirements prescribed by the relevant directives.

At the moment, NANDO [15] database comprises 36 registered bodies competent to perform conformity assessment of medical devices in accordance with Regulation 2017/745/EU which indicates a significantly lower number in relation to the number of notified bodies in accordance with the Directive 93/42/EEC when there were 58 registered bodies. This significantly lower number of notified bodies in accordance with the Regulation 2017/745/EU compared to the number of notified bodies which have been nominated in accordance with the Directive 93/42/EU is related to the stricter requirements specified in the regulation. Experts assume that the number of notified bodies under the MDR does not cover the needs of manufacturers, especially in relation to the existence of clinical competence. In addition, not all notified bodies cover the entire technical spectrum. As the requirements for notified bodies through

the MDR became stricter, it is logical that they also became stricter for the manufacturer themselves. Smaller companies in particular will find it difficult to practically implement the documentation effort and to refinance it on the market. As a result, there is a risk that a number of medical products and medical technology companies will have to leave the market [16].

Notified bodies perform tasks related to conformity assessment procedures, according to the applicable harmonised technical legislation when it requires the participation of a third party. Notified bodies may offer their services in the EU, but also to third countries.

6 Conformity Assessment of Industrial Products

Conformity assessment is a process that is performed by the manufacturer in order to demonstrate if all specific requirements related to the product have been met. The product itself is subject to conformity assessment in the stages of design and production. EU legislation requires the conduction of the process composed of one or two modules of conformity assessment.

The modules for the conformity assessment procedures to be used in the EU harmonised legislation were initially set out in Council Decision 93/465/EEC of 22 July 1993 concerning the modules for the various phases of the conformity assessment procedures and the rules for the affixing and use of the CE conformity marking, which are intended to be used in the technical harmonisation directives. Decision 768/2008/EC, one of three acts of New Legislative Framework, replaced earlier Decision 93/465/EEC. This Decision provides for a menu of modules, enabling the legislator to choose a procedure from the least to the most stringent, in proportion to the level of risk involved and the level of safety required.

In order to ensure equal treatment of economic operators, consistency in the technical application of the modules must be ensured. That can best be achieved through appropriate coordination and cooperation between notified bodies. Manufacturers should be able to choose the procedure of conformity assessment/module in accordance with applicable harmonised EU legislation, in respect of a particular product. The following criteria should give the manufacturer an insight into selection of the appropriate conformity procedure/module:

(a) whether the module concerned is appropriate to the type of product;
(b) the nature of the risks entailed by the product and the extent to which conformity assessment corresponds to the type and degree of risk;
(c) where third party involvement is mandatory, the need for the manufacturer to have a choice between quality assurance and product certification modules;
(d) the need to avoid imposing modules which would be too burdensome in relation to the risks covered by the legislation concerned.

Conformity assessment and conformity assessment modules, although already present in EU countries for a long time, still not have a satisfactory application in

countries that are on the path of integration into the EU. In order to adequately implement the requirements of the corresponding directives/regulations/harmonised standards or other recognized normative documents, there are numerous requirements to be fulfilled, but mainly very competent-trained staff and adequate testing laboratory infrastructure and of course manufacturers who want to place their products on the market.

Despite the presence of government institutions in developed countries whose responsibility is to monitor the market, it is essential that every user or citizen is aware when purchasing a medical product with a measuring function to compare and ensure compliance with the regulations presented in this chapter [17]. Conformity assessment procedures that are applied, for example, to non-automatic weighing instruments in accordance with Directive 2014/31/EU, perhaps the most common used measuring instruments around the world, refer to different accuracy classes, but according to the information in the NANDO database, conformity assessment (different modules) are applied (beside accuracy classes) to the following categories of non-automatic weighing instruments:

- determination of mass for commercial transactions
- determination of mass for the application of laws or regulations or for an expert opinion given in court proceedings
- determination of mass for the calculation of a toll, tariff, tax, bonus, penalty, remuneration, indemnity or similar type of payment
- determination of mass in the practice of medicine for weighing patients for the purposes of monitoring, diagnosis and medical treatment
- determination of mass for making up medicines on prescription in a pharmacy and determination of mass in analyzes carried out in medical and pharmaceutical laboratories
- determination of price on the basis of mass for the purposes of direct sales to the public and the making-up of pre packages

Comparing this scope of non-automatic weighing instruments, the scope of medical devices is much more extensive and demanding, in addition to being divided by risk class levels (with 22 classification rules) they are also divided by its type. Medicinal products for the purpose of conformity assessment procedures, and for the given level of risk for the user, are divided into:

- Class I—medical devices with a low level of risk for the user,
- Class IIa—medical devices with a higher degree of risk for the user,
- Class IIb—medical devices with a high degree of risk for the user,
- Class III—medical devices with the highest degree of risk for the user [18].

As found in NANDO database, under MDR conformity assessment can be performed on the following products:

Active implantable devices:

- stimulation/inhibition/monitoring,
- delivering drugs or other substances

- supporting or replacing organ functions
- utilising radiation and other active implantable devices.

Active non-implantable devices for imaging, monitoring and/or diagnosis:

- imaging devices utilising ionizing radiation
- imaging devices utilising non-ionizing radiation
- devices for monitoring of vital physiological parameters.

Active non-implantable therapeutic devices and general active non-implantable devices:

- utilising ionising radiation
- utilising non-ionizing radiation
- utilising hyperthermia/hypothermia
- shock-wave therapy (lithotripsy)
- stimulation or inhibition
- extracorporeal circulation, administration or removal of substances and hemapheresis
- respiratory devices
- wound and skin care
- ophthalmologic device
- ear, nose and throat
- surgical devices
- prostheses, devices for rehabilitation and devices for patient positioning and transport
- processing and preservation of human cells, tissues or organs including in vitro fertilisation (IVF) and assisted reproductive technologies (ART)
- Software
- Medical gas supply systems and parts thereof cleaning, disinfection and sterilisation
- Other active non-implantable devices (not listed above).

Non-active implants and long term surgically invasive devices:

- cardiovascular, vascular and neurovascular implants
- osteo- and orthopaedic implants
- dental implants and dental materials
- soft tissue and other implants.

Non-active non-implantable devices:

- anaesthesia, emergency and intensive care
- administration, channelling and removal of substances, including devices for dialysis
- guide catheters, balloon catheters, guidewires, introducers, filters, and related tools
- wound and skin care
- orthopaedic and rehabilitation devices

- ophthalmologic devices
- diagnostic devices
- instruments
- dental materials
- used for contraception or prevention of the transmission of sexually transmitted diseases
- for disinfecting, cleaning and rinsing
- for processing and preservation of human cells, tissue or organs including in vitro fertilisation (IVF) and assisted reproductive technologies (ART)
- composed of substances to be introduced into the human body via a body orifice or the dermal route
- used in healthcare and other non-active non-implantable devices.

A very important role in the preparation of guidelines related to the work of notified bodies has Medical Device Coordination Group (MDCG). MDCG deals with key issues from the medical devices sector, from Notified Body oversight or standardisation to market surveillance, passing by international matters, new technologies and clinical investigation [19].

Its expertise originates from its division in 13 subgroups, which respectively provide advice and draft guidance on their expertise field. One of those 13 subgroups is Notified bodies oversight (NBO). This subgroup shares experiences and exchanges views on issues relating to notified bodies and the application of conformity assessment procedures with the aim of a consistent application of requirements and procedures. It drafts technical recommendations on matters relating to notified bodies and conformity assessment [20]. In the "Blue Guide" [21] on the implementation of EU rules on the products, the modules that are used to carry out conformity assessment are listed. In total, there are eight modules labelled with letters A through H, while some of them have variants. Modules specify responsibilities of the manufacturer and level of participation of in-house accredited bodies or notified bodies for conformity assessment (Table 1.). It is important to notice that an in-house body cannot act as a notified body, but they must demonstrate the same technical competence and impartiality to external bodies through accreditation as notify bodies. The following tables show modules in accordance with the "Blue guide", their description and related standards which have to be applied (or combination) in order to fulfil requirements of conformity assessment.

For the field of medical devices, conformity assessment modules are not labelled by letters, but compared to the modules in table above they can be recognised as modules D, B and F.

The modules of conformity assessment in accordance with MDR [22] are recognised as:

Annex IX: conformity assessment based on a quality management system and on an assessment of technical documentation.

Annex X: conformity assessment based on type-examination.

Annex XIA: conformity assessment based on production quality assurance.

Annex XIB: conformity assessment based on product verification.

Table 1 Overview of modules

Module	Description of the module
A Internal production control	Covers both design and production The manufacturer himself ensures the conformity of the products to the legislative requirements (no EU-type examination)
A1 Internal production control plus supervised product testing	Covers both design and production. A + tests on specific aspects of the product carried out by an in-house accredited body or under the responsibility of a notified body chosen by the manufacturer
A2 Internal production control plus supervised product checks at random intervals	Covers both design and production. A + product checks at random intervals carried out by a notified body or an in-house accredited body
B EU-type examination	Covers design. It is always followed by other modules by which the conformity of the products to the approved EU-type is demonstrated. A notified body examines the technical design and/or the specimen of a type and verifies and attests that it meets the requirements of the legislative instrument that apply to it by issuing an EU-type examination certificate. There are 3 ways to carry out an EU-type examination: (1) production type, (2) combination of production type and design type and (3) design type
C Conformity to EU-type based on internal production control	Covers production and follows module B Manufacturer must internally control its production in order to ensure product conformity against the EU-type approved under module B
C1 Conformity to EU-type based on internal production control plus supervised product testing	Covers production and follows module B. Manufacturer must internally control its production in order to ensure product conformity against the EU-type approved under module B. C+ tests on specific aspects of the product carried out by in-house accredited body or under the responsibility of a notified body chosen by the manufacturer (*)
C2 Conformity to EU-type based on internal production control plus supervised product checks at random intervals	Covers production and follows module B. Manufacturer must internally control its production in order to ensure product conformity against the EU-type approved under module B. C+ product checks at random intervals tests on specific aspects of the product carried out by a notified body or in-house accredited body
D Conformity to EU-type based on quality assurance of the production process	Covers production and follows module B. The manufacturer operates a production (manufacturing part and inspection of final product) quality assurance system in order to ensure conformity to EU type. The notified body assesses the quality system

(continued)

Table 1 (continued)

Module	Description of the module
D1 Quality assurance of the production process	Covers both design and production. The manufacturer operates a production (manufacturing part and inspection of final product) quality assurance system in order to ensure conformity to legislative requirements (no EU-type, used as in module D without module B). The notified body assesses the production (manufacturing part and inspection of final product) quality system
E Conformity to EU-type based on product quality assurance	Covers production and follows module B. The manufacturer operates a product quality (=production quality without the manufacturing part) assurance system for final product inspection and testing in order to ensure conformity to EU-type. A notified body assesses the quality system. The idea behind module E is similar to the one under module D: both are based on a quality system and follow module B. Their difference is that the quality system under module E aims to ensure the quality of the final product, while the quality system under module D (and D1 too) aims to ensure the quality of the whole production process (that includes the manufacturing part and the test of final product). E is thus similar to module D without the provisions relating to the manufacturing process
E1 Quality assurance of final product inspection and testing	Covers both design and production. The manufacturer operates a product quality (= production quality without the manufacturing part) assurance system for final product inspection and testing in order to ensure conformity to the legislative requirements (no module B (EU-type), used like E without module B). The notified body assesses the quality system. The idea behind module E1 is similar to the one under module D1: both are based on a quality system. Their difference is that the quality system under module E1 aims to ensure the quality of the final product, while the quality system under module D1 aims to ensure the quality of the whole production process (that includes the manufacturing part and the test of final product). E1 is thus similar to module D1 without the provisions relating to the manufacturing process
F Conformity to EU-type based on product verification	Covers production and follows module B. The manufacturer ensures compliance of the manufactured products to approved EU-type. The notified body carries out product examinations (testing of every product or statistical checks) in order to control product conformity to EU-type. Module F is like C2 but the notified body carries out more systematic product checks
F1 Conformity based on product verification	Covers both design and production. The manufacturer ensures compliance of the manufactured products to the legislative requirements. The notified body carries out product examinations (testing of every product or statistical checks) in order to control product conformity to the legislative requirements (no EU-type, used like F without module B) Module F1 is like A2 but the notified body carries out more detailed product checks

(continued)

Table 1 (continued)

Module	Description of the module
G Conformity based on unit verification	Covers both design and production. The manufacturer ensures compliance of the manufactured products to the legislative requirements. The notified body verifies every individual product in order to ensure conformity to legislative requirements (no EU-type)
H Conformity based on full quality assurance	Covers both design and production. The manufacturer operates a full quality assurance system in order to ensure conformity to legislative requirements (no EU-type). The notified body assesses the quality system
H1 Conformity based on full quality assurance plus design examination	Covers both design and production. The manufacturer operates a full quality assurance system in order to ensure conformity to legislative requirements (no EU-type). The notified body assesses the quality system and the product design and issues an EU design examination certificate. Module H1 in comparison to module H provides in addition that the notified body carries out a more detailed examination of the product design. The EU-design examination certificate must not be confused with the EU-type examination certificate of module B that attests the conformity of a specimen 'representative of the production envisaged', so that the conformity of the products may be checked against this specimen. Under EU design examination certificate of module H1, there is no such specimen. EU design examination certificate attests that the conformity of the design of the product has been checked and certified by a notified body

Probably the most demanding of the conformity assessment procedures is the conformity assessment in accordance with the type examination module, which requires well developed laboratories and competent staff. In the field of medical products 14 out of a total of 36 notified bodies, can provide type examination services, but not all of the providing this kind of service for all types of medical products.

There are 4 (actually 3) possible involvements by Notified Bodies:

No Notified Body involvement at all: module A;

Involvement, but only in the production phase: modules A1, A2;

Involvement in the design phase: module B followed by production phase: modules C1, C2, D, E, F;

Involvement in design and production phases: modules D1, E1, F1, G1, H, H1 [23].

Some of the conformity assessment modules are only possible in combination with others, i.e. in order to carry out a certain conformity assessment module, an earlier one had to be carried out first.

For example, Non-automatic weighing instruments 2014/31/EU, which requires combination of the following modules B + D or B + F, Modules D1 or F1 or Module G.

7 Standards Used in Manufacturing Process

Standards aren't the same as regulations and following a standard doesn't guarantee that you are within the relevant laws. In fact standards rarely cite the law as legislation could change within the lifetime of the standard.

To successfully carry out the harmonization process within the legal metrology framework, it is necessary to take appropriate steps by harmonizing requirements for benchmarks, test methods, test reports, and certificates, which the government often relies on standards for when creating legislation or guidance documents to establish technical details, enabling the legislation to focus on long-term policy objectives such as product safety or environmental protection [24].

In a case like this, compliance with the standard will often mean you're compliant with the relevant legislation, although there are usually ways of being compliant with legislation without using a standard.

Standards are voluntary which means that there is no automatic legal obligation to apply them. However, laws and regulations may refer to standards and even make compliance with them compulsory.

A technical regulation is a Government document that lays down product characteristics or their related processes and production methods, including the applicable administrative provisions, with which compliance is mandatory. It may also include or deal exclusively with terminology, symbols, and packaging, marking or labelling requirements as they apply to a product, process or production method. No consensus is necessary for establishment of the regulation.

The difference between a standard and a technical regulation lies in compliance. While conformity with standards is voluntary, technical regulations are by nature mandatory.

International standards should be used as a basis for preparing technical regulations except when they are not appropriate to fulfil legitimate interests, for instance, because of fundamental climatic or geographic factors or fundamental technological problems.

For a government, avoiding unnecessary obstacles to trade means that when it is preparing a technical regulation to achieve a certain policy objective—whether protection of human health, safety, the environment, etc.—the regulation shall not be more trade-restrictive than necessary to fulfil the legitimate objective.

Technical regulations adopted in pursuance of legitimate interests and in accordance with relevant international standards are presumed not to create unnecessary obstacles to international trade.

European harmonised standards are those that are considered to satisfy the relevant essential safety requirements specified in European product directives or regulation.

For example in the field of metrology there are 23 harmonized standards related to the MID (2014/32/EU) and 17 normative documents which are also used in conformity assessment procedures. Comparing to the field of medical devices, we can find 17 harmonised standards linked to the 2017/745/EU regulation [25]. This may lead to conclusion that MID has stricter requirements.

The difference is reflected in the fact that harmonized standards and normative acts in the field of metrology are directly related to individual measuring instruments covered by the MID, while harmonized standards in the field of medical products are related to the general requirements of medical products, and the number of standards that are directly related to individual medical products is significantly larger.

In the field of medical devices, used in manufacturing process, there are ca. 200 standards among those which are harmonized, which have been issued under the European Committee for Standardization CEN (without revision), and close to 100 standards issued under the European Committee for Electrotechnical Standardization CENELEC (without revision). Taking into account such a large number of standards regulating the requirements for a particular product group, it is easy to conclude that this area of manufacturing presents an area where most attention is paid in relation to the safety of the product itself and its users.

One of the most widely used standards in the area of manufacturing of the medical devices is the standard IEC 60601-1 Medical electrical equipment—Part 1: General requirements for basic safety and essential performance.

Standard IEC 60601-1 is a basic document comprised of two parts that relate to the safety of medical devices (collateral standards) and to various types of medical equipment (particular standards). The basic version of the standard was published for the first time in 1977 and was related to the issues of electrical and mechanical safety.

Standards marked with IEC 60601-1-X are collateral standards (where X represents sub-standards, altogether 11).

Standards marked with IEC 60601-2-X are specific standards (where X represents sub-standards, altogether 58).

The basic standard IEC 60601-1 is applied for the purpose of basic safety and essential performance of Medical Electronical Equipment and Medical Electrical Systems. The content of the standard describes protection against electrical Hazards from Medical Electrical Equipment, protection against mechanical Hazards of Medical Electrical Equipment and Medical Electrical Systems, protection against unwanted and excessive radiation Hazards, and protection against excessive temperatures and other Hazards.

In this part of the chapter the main activities on protection against electrical Hazards from Medical Electrical Equipment will be described, since the patients and operators are exposed to this hazard the most when operating or using the equipment which did not fulfil the requirements stated in the corresponding standard. Requirements set in the standard IEC 60601-1 give the manufacturer a possibility to better understand how to reduce risks of harm or to bring them to the acceptable limits.

Protection against electrical Hazards from Medical Electrical Equipment in accordance with standard IEC 60601 covers requirements related to maximum permissible voltage, current, energy, power sources, needed insulation, testing of leakages, etc. In order to satisfy prescribed limitation of voltage, current or energy, means for reducing the risk due to electric shock in accordance with the requirements of standard IEC 60601-1 which can be divided in two categories:

- Means of patient protection (MOPP)—Means of protection for reducing the risk of electric shock to the patient.
- Means of operator protection (MOOP)—Means of protection for reducing the risk of electric shock to persons other than the patient.

Standard also covers specific measurement tests of current leakage, insulation requirements, creepage distances and air clearances.

Another very important harmonized standard for the manufacturers, among the 17 connected to the regulation 2017/745/EU, from the point of a high quality of medical products, is standard ISO 13485 [26].

ISO 13485 is an internationally recognized standard for quality management systems in the medical products industry. It specifies the requirements for a quality system in which an organization must demonstrate its ability to deliver medical products, and that the services associated with this can consistently meet customer requirements and relevant laws and regulations. It is designed and intended for use by organizations to carry out the design, development, production, installation, maintenance and sale of medical products.

The primary objective of ISO 13485 is to establish a system that is fully capable of meeting legal and quality system requirements. ISO 13485 is an independent standard. It is largely based on the structure of ISO 9001 [27], but includes certain specific requirements for medical products such as: risk analysis, sterile production and traceability.

It is designed to be used by organizations throughout the life cycle of a medical device, from initial conception to production and post-production, including final decommission and disposal. It also covers aspects such as storage, distribution, installation and servicing, and the provision of associated services. In addition, the standard can be used by other internal and external parties, such as certification bodies, to help them with their certification processes, or by supply chain organizations that are required by contract to conform. ISO 13485 helps an organization design a quality management system that establishes and maintains the effectiveness of its processes. It reflects a strong commitment to continual improvement and gives customers confidence in its ability to bring safe and effective products to market [28].

8 Medicine in the Field of Legal Metrology

Medical measurements are an essential component of everyday life and serve as a fundamental process for the prevention, diagnosis, and treatment of diseases. In Europe, there is a growing focus on metrology and conformity assessment decisions, which are crucial for carrying out accurate measurements that safeguard public health, particularly in light of the digital transformation's impact on medical device management, where data gathering and evidence-based informed decision-making have become imperative.

Products with a measuring function must be designed and manufactured in such a way to provide sufficient accuracy and stability within appropriate limits of accuracy, taking into account the intention of the use of the product. The accuracy limits (permissible errors) are specified by the manufacturer himself. The measurements done by the device with a measuring function must be expressed in legal units of measurement in accordance with the provisions of Directive 80/181/EEC [29].

Metrology with its measurements is an integral part of our daily life. All measurements which are carried out with the purpose of any economic transactions, or measurements with which it's possible to take certain legal measures against or in someone's benefit, protection in the field of health and the environment, are to be classified as measurements of legal metrology. Individual governments proscribe regulations under legal metrology to meet its needs, except for the harmonized area which is equal and obligatory in all member states (11 measuring instruments, MID 2014/32/EU and NAWI [30] 2014/31/EU). One issue is common for all state economies and that is a fact that legal metrology is founded for the purpose of protection of the consumers (end users). OIML—International Organization of Legal Metrology has divided this category of metrology into four parts.

Those parts are:

- Legal Metrology and Trade
- Legal Metrology and Safety
- Legal Metrology and Health
- Legal Metrology and the Environment.

The accurate and precise measurements in the field of medicine allow easier diagnosis and identification of diseases on the basis of which it is possible to precisely determine the appropriate treatment of the patient, in order to help the patient in the best and safest way to receive effective treatment, but all through the usage of adequate medical instruments/ devices which fulfil the requirements described in the relevant legislation and standards.

In accordance with OIML D1 [31] document, governmental regulatory responsibilities include **health**, safety and environmental law. While these functions are disparate in nature, a common feature is that compliance with the law depends on measurement results. The scope of legal metrology may be different from country to country.

Therefore, the process of measurement is of direct concern to the government. Providing the laws and regulations, controlling measurement through market supervision and developing and maintaining the infrastructure that can support the accuracy of these measurements (e.g. through traceability) is essential in fulfilling the role of government.

The scope of the legal metrology regulations (e.g. which types of measurements and measuring instruments or systems are subject to legal requirements) will depend on those markets that are important to the economy, on the categories of users that the government considers necessary to protect, and on the ability of the users to protecting themselves against abuse.

Since there are only 11 harmonized instruments, it is easy to conclude that the non-harmonized sector comprises of much higher number of instruments.

Non-harmonised sectors [32] are not subject to common EU rules and may come under the national rules. These sectors should still benefit from Treaty provisions governing free movement of goods according to Arts. 34–36 TFEU (Treaty on the Functioning of the European Union). National rules on these products are subject to a notification procedure that ensures they do not create undue barriers to trade.

In order to ensure the free movement of goods in non-harmonised sectors, the principles of mutual recognition, the 98/34 notification procedure and the application of Arts 34–36 TFEU are essential.

In some regions, due to the treaties or agreements, regional legislation may have precedence over national laws and regulations or may be recommended to national authorities. This is the case for example in the European Union, where European Regulations and European Directives are accorded higher status than national legislation.

Referring again to OIML Document D1 „Considerations for a Law on Metrology “, the recommendation for government bodies building their metrology systems are encouraged to keep the following:

The priority is to set up the legal provisions related to the status of the bodies to which tasks will be allocated, and the financial provisions that will ensure their sustainability (national institutes, accreditation bodies), the general framework for legal metrological control and the first list of priorities for categories to be subjected to legal control, and the infringements, penalties and the powers of agents in charge of metrological supervision.

The scope of legal metrology, that is the list of categories of measuring instruments, must start with the most important categories for which the available resources allow the regulation to be correctly enforced. The scope can then be progressively extended as additional resources become available.

The obligations resulting from the OIML Treaty and from the WTO TBT Agreement (obligation to use OIML Recommendations as far as possible, and encouragement by the TBT Agreement to participate in OIML recognition and acceptance arrangements) should also be taken into account, as well as other obligations deriving from regional treaties or agreements.

Measuring instruments under legal metrology have to be regularly verified. Verification [33] of a measuring instrument represents conformity assessment procedure (other than type evaluation) which results in the affixing of a verification mark and/or issuing of a verification certificate.

As described in OIML Document D1 “Fields of use of measuring instruments subject to verification” Instruments, substances, and devices used in the diagnosis and treatment of humans and animals, in the manufacture of medicines, and in the monitoring of the medical environment (patient and hospital) should be considered for verification.

OIML has published a certain number of recommendations which indicate on verification procedures of medical devices. This will be described more in detail in

the chapter dedicated to legal metrology. Medical devices covered by International Organization of Legal Metrology [34] are as follows:

- Medical syringes, covered by OIML recommendation R 26 (1978)
- Standard graduated pipettes for verification officers, covered by OIML recommendation R 40 (1981)
- Electroencephalographs—Metrological characteristics—Methods and equipment for verification, covered by OIML recommendation R 89 (1990)
- Electrocardiographs—Metrological characteristics—Methods and equipment for verification, covered by OIML recommendation R 90 (1990)
- Measuring instrumentation for human response to vibration, covered by OIML recommendation R 103 (1992)
- Pure-tone audiometers (including Annexes A to E), covered by OIML recommendation R 104 (1993)
- Clinical electrical thermometers for continuous measurement, covered by OIML recommendation R 114 (1995)
- Clinical electrical thermometers with maximum device, covered by OIML recommendation R 115 (1995)
- Equipment for speech audiometry, covered by OIML recommendation R 122 (1996)
- Non-invasive non-automated sphygmomanometers, covered by OIML recommendation R 148 (from 2020)
- Non-invasive automated sphygmomanometers, covered by OIML recommendation R 149 (from 2020).

OIML has covered only a part of medical devices with measuring function; however the number of medical devices in use is much higher. For medical devices that are applied in the EU but which are not covered by legal metrology in some countries calibration process has to be ensured with an adequate traceability chain. Requirements for harmonizing a large number of medical devices in legal metrology are constantly increasing. There is growing interest in the role of metrological decisions and conformity assessment, notably where measurements are made to safeguard health [35].

Measurements are essential in medical diagnosis and the prevention and treatment of diseases, risk assessment and monitoring of patients. Such measurements are performed every day; moreover, as the measurement results become more important in medicine so they must be more accurate and also comparable in different locations over time. Only then is it possible to optimize patient care and to efficiently manage healthcare funds.

Some countries of South-east Europe, namely Bosnia and Herzegovina and Serbia, (which are not members of the EU), are members of WELMEC (European Cooperation in Legal Metrology) and OIML, who are regularly taking part in activities of those organisations. The national metrology institutes of those countries have introduced certain medical devices in the field of legal metrology in accordance with their national regulation, as part of regular subject of legal control, namely verification.

Medical instruments with measuring function, which are part of the Legal metrology system in B&H and Serbia, are as follows:

- Defibrillator,
- Infusomats and perfusors,
- Patient monitors,
- Neonatal and paediatric incubators,
- Respirators,
- Anaesthesiology machines,
- Therapeutic ultrasound devices,
- Dialysis machines,
- Electrocardiographs ECG/EKG.

Beside those medical devices, Serbia has also measuring devices that are an integral part of high-frequency surgical knives and high-frequency surgical accessories as subject of national control [36].

This action proved to be very successful, according to the feedback from the legal entities responsible for performing verification in this subjected field. The majority of devices tested have shown certain non-conformities related to the requirements prescribed in legal documents and/or by the manufacturer [37–41].

Unlike other measuring instruments covered by legal metrology, many of the medical devices need to be traceable to one measuring standard which is not fully developed yet. The future of development in this field of metrology lies in facilitating the process of calibration, i.e. establishment of a traceability chain via a single measuring standard for a certain type of medical device.

Turkey has also already recognised the importance of metrology in medicine and has initiated via Turkish Institute of Metrology (UME) [42] a study on appropriate traceability of medical devices. The aim of the study is to develop a five year roadmap and a plan for providing reliability and metrological traceability in medical measurements. To get closer to its intended aim, UME has established a Medical metrology research laboratory.

Comparing the current situation of those countries dealing with medical instruments in a controlled area it is obvious that the main issue in general refers to how to ensure or improve adequate metrological traceability. Looking at the history in the field of medical devices and the connection with metrology, it can easily be concluded that OIML recognized this connection a long time ago. More and more authorised state institutions recognize this connection and introduce a certain number of medical devices as subject of legal control. Medical devices which are currently under legal control are those which are most often used in practice and where a reliable result based on the measured results is key in the treatment of patients.

9 Regulation of Artificial Intelligence Usage in Medical Devices

Since the era of digitization begun in the late twentieth century, continuous advancements have been made in the field [43]. Even though most people remained unaware of it, the 4th industrial revolution [44, 45] has already impacted life as we know it and most of our daily activities rely on the advancements provided for humans by means of industry 4.0. Industry 4.0, also known as the fourth industrial revolution, refers to the integration of advanced technologies and systems to automate and optimize various industrial processes. In the healthcare sector, Industry 4.0 has the potential to revolutionize the way healthcare is delivered, managed, and monitored.

The healthcare sector is an inexhaustible source of data gathered every day through measurements of patient-related parameters or device-related parameters. Although modern technology has accelerated the development of new diagnostic procedures and interventions, it remains tightly controlled by human operations. Medical devices, which assist medical practitioners in diagnosing and treating diseases, have evolved significantly over time and have been modernized alongside other devices used in practice. The fourth industrial revolution has largely influenced the improvement of these devices, paving the way for process digitalization and the utilization of data generated by IoT networked devices. To advance healthcare, data generated by medical devices must be understood, stored long-term in cloud-based servers, and selectively used to develop "smart solutions." Big data structures are at the center of all "smart" solutions, with one way to make devices smart being to supply them with AI-based algorithms. AI-based methods are evaluated based on their accuracy when compared to that of medical professionals. To be considered a potential candidate for further development, the AI model must be "trained" with a large dataset that covers as much variation in input parameters as possible and "validated" by comparing their outputs with that of an experienced consortium of medical professionals. Medical professionals who work with medical devices daily are beginning to appreciate the potential that technology advancements have for patient diagnosis, treatment, and prognosis.

The European Commission has taken a proactive approach towards AI regulation in healthcare. In April 2021, the European Commission proposed new rules for AI that would apply to all AI systems used in the European Union (EU), including those used in healthcare. The proposal is a part of a broader strategy to establish Europe as a global leader in AI development and deployment. The proposed rules aim to ensure that AI systems are safe, transparent, and accountable. Regardless of their use or purpose, the proposed regulations will require compliance with strict requirements and standards for AI systems. Specifically, the proposed rules would classify AI systems into four categories based on their risk level: unacceptable risk, high risk, limited risk, and minimal risk. Healthcare AI systems are likely to be classified as high-risk or limited-risk systems, depending on their intended use. High-risk systems may include AI systems which are used for clinical decision-making, while limited-risk systems may include AI systems used for administrative purposes.

Also, high-risk systems would require mandatory third-party conformity assessments before they can be placed on the market, and would also be subject to ongoing surveillance and monitoring. The goal of these assessments is to ensure that high-risk AI systems are safe, reliable, and comply with relevant regulations. Ongoing surveillance and monitoring would help identify any potential issues or risks with AI systems that have already been placed on the market. Limited-risk systems would require less stringent requirements, but would still need to comply with transparency and data protection requirements, so that users can understand how the AI system is making decisions. Data protection requirements would also ensure that personal data is processed in a lawful and transparent way. The proposed rules also address ethical concerns related to AI in healthcare, such as ensuring that AI systems are designed to respect fundamental rights, and that their outputs are explainable and auditable. This means that AI systems should not be used to discriminate against individuals based on factors such as race, gender, or age. Users should be able to understand how the system arrived at its decision. The European Commission has emphasized the need for human oversight and intervention in AI decision-making, particularly in cases where AI systems are used to make decisions that could have significant impacts on individuals' health or well-being, meaning that AI systems should not be used as a replacement for human decision-making, but rather as a tool to support it [46, 47].

For medical devices—the European Union (EU) has introduced regulations to govern the usage of artificial intelligence (AI)s. These regulations require that AI-based medical devices comply with the EU's existing regulatory framework for medical devices, which includes the Medical Device Regulation (MDR) and the In Vitro Diagnostic Regulation (IVDR). AI-based medical devices must meet the same safety and performance standard as other medical devices. In addition to complying with these regulations, AI-based medical devices must also adhere to specific requirements related to their AI components. These requirements include ensuring that the algorithms used in the device are transparent, explainable, and verifiable, and that the device is designed in a way that minimises the risk of error or bias. The EU regulations also require that AI-based medical devices undergo a thorough assessment of their safety and performance before being placed on the market. This assessment includes a review of the device's technical documentation, clinical data, and risk management plan, and must be carried out by a notified body. This ensures that AI-based medical devices are safe and effective, and provide accurate and reliable diagnostic results.

The future of AI regulation is a topic of ongoing debate and discussion. As AI technology continues to advance and become more widespread in various industries, including healthcare, there is increasing recognition of the need for effective regulation to ensure that these technologies are developed and used responsibly. Overall, the regulations aim to ensure that AI-based medical devices meet the same safety and performance standards as traditional medical devices, while also addressing the unique challenges and risks associated with the use of AI in healthcare.

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