ANALYSIS OF LEGAL AND REGULATORY FRAMEWORKS IN DIGITAL HEALTH: A COMPARISON OF GUIDELINES AND APPROACHES IN THE EUROPEAN UNION AND UNITED STATES

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Abstract

The advent of digital technology in healthcare presents opportunities for the improvement of healthcare systems around the world and the move towards value-based treatment. However, this move must be accompanied by strong legal and regulatory frameworks that will not only facilitate but encourage the good use of technology. The goal of the study was to assess the amenability and furtherance of regulatory frameworks in digital health by evaluating and comparing the processes, effectiveness and outcomes of these frameworks in the European Union and United States. **Methods:** This study incorporated two research methodologies. The first was a research of current legal and regulatory frameworks in digital health in the European Union and United States. A comprehensive online search for publications was carried out which included laws, regulations, policies, green papers, guidelines and recommendations. This research was complemented with interviews of five purposively sampled key informants in the legal and regulatory landscape. **Results**: Mind-maps revealed key features and challenges of the digital health field in the topics of the current state of regulation of digital health in the EU, Germany and US, regulatory pathways for digital health devices, protection and privacy of health data, mobile health validation, risk-based classification of medical devices, regulation of clinical decision support systems, telemedicine, artificial intelligence and emerging technologies, reimbursement for digital health services and liability for digital health products. The experts expressed and explained key points where current regulation is deficient. The review of the legal frameworks revealed deficiencies which provide opportunities and recommendations to further develop and strengthen the regulatory landscape. **Conclusions**: A key element to a robust regulatory framework is the ability to ensure trust and confidence in using digital health technology. Technology must measure the impact on quality of life and burden of disease and not merely involve the collection of data.

Keywords: legislation; regulation; technology; digital health; telemedicine; medical device legislation

Introduction

Digital technology in healthcare presents many opportunities for the improvement of healthcare systems around the world. It is one of the most significant tools that will enhance the move towards value-based treatment. However, this move needs to be accompanied by strong legal and regulatory frameworks that will not only facilitate but encourage the good use of digital technology. Despite various frameworks, there still appear to be barriers to the quick adoption of technologies. Research on the digitalisation of healthcare in Germany conducted by interviews with experts on barriers and solutions for digital health, portends that the degree of digitalisation in German healthcare is low when compared internationally and with other German industries.[1] It is of utmost importance that the technology sector forms and expands partnerships with regulatory authorities, so that future medical devices follow a regulatory framework that fosters rapid access to innovative technologies.

Though medical devices are bound to the rules of the Medical Device Regulation (MDR), mHealth applications seldom undergo the critical evaluation of the MDR as compared to conventional medical devices.[2] The difficulties encountered by users who wish to identify an mHealth application that matches their ideas include inadequate or incomprehensible mobile app store descriptions (in terms of content and language) that do not provide particulars of the functionalities, content offered and information concerning limitations, data protection, or even the manufacturers themselves.[3]

This research was conducted to analyse the legal and regulatory aspects of the digital health field and competences

of regulatory bodies primarily in Germany and the United States. The goal of the study was to assess the amenability and furtherance of regulatory frameworks in digital health by evaluating and comparing legal requirements that are currently in use in the European Union (EU) and United States (US), with respect to the processes, effectiveness and outcomes of the adoption of the current regulatory guidelines.

Methods

This study involved: review of the literature related to legal and regulatory frameworks in digital health, primarily focusing on the European Union and the United States, and interviews with key informants on the legal and regulatory landscape in digital health were undertaken.

A comprehensive online search for publications on legal and regulatory frameworks in digital health was conducted. This included a search of laws, regulations, position statements, policies, green papers, guidelines and recommendations produced by governmental, professional organisations and other relevant bodies for use in the EU and the US. The search was supplemented with journal articles, reports, editorials, working papers, commentaries, reviews and relevant grey literature related to regulatory frameworks of digital health. A list of terms and keywords (related to regulation in digital health) with all possible synonyms and abbreviations for each keyword was developed. A search was then applied using the keywords and Boolean terms in order to retrieve relevant articles published between 1 January

2014 and 31 October 2019. Searches were carried out in each of ten topics as shown in Table 1. An example of the search strategy used was ("Digital Health" OR "eHealth" OR "mHealth" OR "pHealth") AND ("Regulation" OR "Regulatory frameworks" OR "Laws" OR "Legal" OR "Legislation" AND "European Union" OR "Germany" OR "United States"). The databases searched were: European Commission (ec.europa.eu), Bundesgesundheitsministerium für Gesundheit (bundesgesundheitsministerium.de), Food and Drug Administration (fda.org), Google Scholar and web sites of companies providing 'proxy' or 'surrogate' regulations, web portals of professional organisations, institutions, councils and committees concerned with governance.

The retrieved documents were reviewed and evaluated according to the following inclusion criteria: they represented the most recent normative documents from national organisations, regulatory committees, professional associations and journal publications which described guidelines, recommendations or policies on the legal and regulatory frameworks applicable to digital health enforced in the EU and US. Documents whose scope did not serve the purpose within the area of regulatory development in digital health, abstracts where full texts were unavailable, and publications in languages other than English and German were excluded. On selection of the documents, the literature was analysed to find strengths and weaknesses in the amenability of the regulation for digital health. The reviewed documents were analysed by pointing out their strengths and weaknesses in the context of the amenability of frameworks

Table 1. Content of papers reviewed in each of the categories studied.

Topic	Content Analysed
Current state of regulation of digital health in the EU, Germany, US	Status, challenges of digital health frameworks, Legal basis of regulatory policies in Germany
Regulatory pathways for digital health devices	Rules of the Medical Device Regulation 2017/745, Pre-certification program of the Food and Drugs Administration
Protection and privacy of health data	Protection and privacy of data within the General Data Protection Regulation, secondary use of data for research
Mobile health (mHealth) validation	Policies, guidelines on the regulation of mobile medical applications issued by the European Commission and the Food and Drugs Administration
Risk-based classification of medical devices	Basis of classification of medical devices on risk as per the International Medical Device Regulators Forum
Regulation of clinical decision support systems	Regulation of clinical decision support software within the EU and process of regulation in the US
Regulation of telemedicine	Regulatory barriers to the access and uptake of telemedicine
Regulation of artificial intelligence and emerging technologies	Requirements of regulation of emerging digital technology solutions
Reimbursement for digital health services	Reimbursement policies, proposals and challenges for digital health services in the EU and US
Liability for digital health products	Guidelines and challenges for liability related to telemedicine and digital health

of digital health. A tabulation of the perceived strengths and weaknesses was done. A critical discussion of the retrieved documents was done by both the authors.

Interviews were conducted with five key informants, purposively selected based on their knowledge and experience with EU and US law related to digital health. A questionnaire was prepared to reflect the ten key areas of the search strategy (Table 1). The interviewees were briefed about the objectives of the research and interviews were carried out in person or by web conference. After obtaining consent, the interview was recorded, transcribed and handwritten notes made during the interview. The content of the interview text was critically analysed, and recurring themes were noted. A map of keywords and phrases of the thematic content was combined for all five interviews and each of the questions. These were drawn to visually organise the information and show hierarchical relationships among parts of the whole, simulating a 'mind' map. The mind-maps from the interviews formed the basis for the extraction of opinions, ideas, impressions and experiences of the key informants. The main topics, primary opinions and secondary opinions were colour coded as blue, yellow and green respectively (Figure 1). Mind-maps as an aide to analysis were used to organise text fragments from data retrieved from interviews because they afford a great level of flexibility when thematically analysing qualitative data and they are particularly useful for the iterative process of qualitative analysis.[4]

This study was undertaken with the approval of the Ethics Committee of the Deggendorf Institute of Technology.
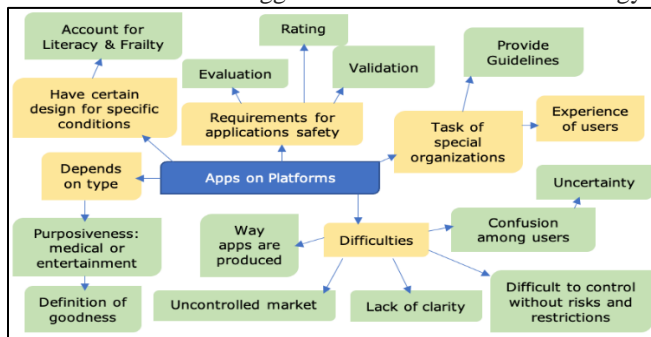

Figure 1. Mind map on the regulation of applications on mobile platforms.

Results

A list of the documents retrieved were as follows: documents for regulation of digital health including software as a medical device in the EU (Table 2), legal framework for regulation of digital health in Germany (Table 3), documents for regulation of digital health including software as a medical device in US (Table 4) and documents for the general regulation of digital health and software as a medical device (Table 5). Each of the selected documents (EU, Germany, US) was analysed in terms of strengths and

weaknesses related to amenability of the regulatory landscape for digital health (Table 6). Using mind-maps of the interview data and a review of current legislation, the inadequacy of regulation of digital health in the EU and in particularly, in Germany, was noted. The frameworks are far from what they should be and are currently in development. Apart a number of policies from the European Commission (e.g. 'Aging well with ICT', 'Silver economy'), current regulation does not accurately address the regulatory needs of the digital health field. The frameworks related to medical devices alone are adequate, but introduce stringent requirements. Frameworks applied to medical devices as compared to those applied to other forms of digital health have different requirements. In Germany, a 'Telematikinfrastruktur' is in place, which is the basis for the regulation of the digital health field. It addresses regulatory needs like regulation of medical devices, telemedicine, regulation of professionals and the Electronic Health Record (elektronische Gesundheitskarte) system. A recent development in Germany is the Digital Supply Act (Digitales-Versorgungs-Gesetz – DVG). This act allows "apps on prescription" and is supported by a fast track assessment by the German Federal Institute for Drugs and Medical Devices.

In evaluating the regulatory field in the United States, especially with regard to the pilot Digital Health Software Precertification Program, it was noted that the Food and Drugs Administration (FDA) has more degrees of freedom to react quickly and effectively in introducing necessary changes in regulation. However, this approach was found to have a major deficiency in that the experts questioned the basis of selection of companies for pre-certification. Secondly, they noted that there is no pre-market and only a post-market surveillance system. On the other hand, the process in the European Union requires prior testing of devices, followed by certification and placement on the market.

Concerning the protection and privacy of data, it was noted that the General Data Protection Regulation (GDPR) is necessary in the current scenario of digitalisation of the healthcare structure. The regulation gives clear definitions to the ownership of data and rights as a private person. The privacy and protection of data by companies is scrutinised more than before, making it possible to uncover previously undetected irregularities. The regulation is especially good for research and secondary use as the source and owner of the data can be traced. On stating that data is for research purposes, anonymisation can be done where the GDPR will not be an obstacle. One expert contended that secondary use should not be of a statistical nature as this is merely an assumption of one's health condition and it is important to get enriched data from the data source. A drawback of the GDPR is that despite its implementation there are cases of misuse as well as difficulties in implementation.

A mind-map on the regulation of mHealth (Figure 1),

showed various aspects required for regulation. The experts stated the need for agencies to provide guidelines on "sensible medical applications," i.e. applications that provide a benefit to the user. The difficulties in regulating mHealth applications stem from the fact that there is no organisation to test or rate all mHealth applications available today.

Secondly, it is difficult to differentiate applications for medical purpose from those meant for entertainment. It is also difficult to control the release of applications, since the placement of restrictions are not effective. In order to regulate applications on mobile platforms, the following was suggested: a system based on the purposiveness of apps,

Table 2. Retrieved documents pertaining to regulation of digital health including software as a medical device in the EU.

Title and Year	Type and Key Normative Content
Manual on Borderline and Classification in the Community-Regulatory Framework for Medical Devices (2019)[5]	Guidance document Clarification for borderline cases of software and mobile applications with examples
ePrivacy Regulation (2019)[6,7]	Document with proposal for regulation of electronic communication based on the GDPR
Legal and Regulatory implications of Artificial Intelligence (2019)[8]	EC report on the identification of legal and regulatory challenges on the usage of AI technology for mHealth, text and data mining
Proposed Guiding Principles for Reimbursement of Digital Health Products and Solutions (2019)[9]	EC guidance document with key principles and proposals in the reimbursement of digital health products and solutions in Europe
Liability for emerging digital technologies (2018)[10]	EC guidance document mapping the liability challenges that occur with emerging digital technologies
Regulation (EU) 2018/1807 of the European Parliament and of the Council (2018)[11]	Document with framework for the free flow of non-personal data in the European Union
Regulation (EU) 2017/745 Of The European Parliament and of The Council (2017)[12]	Document with details of the regulation of Medical Devices; Concepts of EUDAMED and UDI; Rules to classify medical devices into 4 categories; Software that may be used as a medical device
Regulation (EU) 2017/746 Of The European Parliament and of the Council (2017)[13]	Document with details of the regulation of in-vitro diagnostic medical devices; Regulation of software as an in-vitro diagnostic medical device.
Big Data: A complex and evolving regulatory framework (2017)[14]	EC report detailing the regulatory challenges of the big data market, evolving a regulatory framework
Regulation (EU) 2016/679 Regulation (2016) General Data Protection Regulation[15]	Document detailing data protection and privacy for all individual citizens of the European Union and European Economic Area
EU guidelines on assessment of the reliability of mobile health applications (2016)[16]	EC guidance document on the establishment of a framework of safety, quality, reliability and effectiveness criteria for mHealth apps
mHealth sub-group Report on national mHealth strategies (2016)[17]	EC report on the existing strategies, activities and perspectives on mHealth in EU member states
Summary Report on the Public Consultation on the Green Paper on Mobile Health EC Report (2015)[18]	EC report of views and actions to the green paper on mobile health related to data protection, legal framework, patient safety, reimbursement, liability and mHealth role in health care system
Green Paper on mobile Health ("mHealth") (2014)[19]	Green paper on mHealth detailing data protection, security, reimbursement models, liability and the applicable EU legal framework
Existing EU legal framework applicable to lifestyle and wellbeing apps EC Staff Working Document (2014)[20]	EC guidance document with description of the legal framework applicable to lifestyle and wellbeing apps
Council Directive (85/374/EEC) on approximation of laws, regulations and administrative provisions of Member States concerning liability for defective products (1985)[21]	Document for strict liability of damage arising from defective products

Table 3. Retrieved documents pertaining to legal framework for regulation of digital health in Germany.

Title and Year	Type and Key Normative Content
Sozialgesetzbuch Fünftes Buch (SGB V) [Legal Framework For The Introduction Of The Electronic Health Card And The Development Of The Telematics Infrastructure][22]	§ 291a Electronic Health Card - Interoperable, secure telematics infrastructure (eGK) § 291b Society for Telematics - Specification, authorisation, responsibility for operation § 291c Arbitration Board for Association of Telematics § 291d Integration of open interfaces into information technology systems § 291e Interoperability Index § 291f Transmission of electronic letters in the contractual medical care § 291g Technical procedures for telemedical, video consultation on medical findings of radiography
E-Health-Gesetz 2015[22,23,24] [eHealth Act 2015] Includes:	Law for secure digital communication and applications in the healthcare sector as well as the amendment of other laws
Versichertenstammdatenmanagement (VSDM) 2016 [Insured master data management][22,24]	Electronic examination of proof of insurance on eGK, updating of insured master data
Stationäre und mobile Endgeräte der Versicherten 2016 [Stationary and mobile devices of insured persons][22,24]	Concept for connecting devices of the insured the telematics infrastructure
Telemedizin: Videosprechstunde 2016 [Telemedicine: Teleconsultation] [22,24]	Definition, validation of adaptation of standard assessment to videoconsultation
Konsiliarische Befundbeurteilung von Röntgenaufnahmen 2016 [Assessment of radiographs][22,24]	Determination of adaptation of the uniform assessment standard for radiographic examination
Interoperabilitätsverzeichnis (IOPVZ) und Informationsportal 2017 [Interoperability Index] [22,24]	Construction of an electronic interoperability directory
E-Medikationsplan (eMP) 2017 [eMedication Plan] [22,24]	Determining the content and structure of the medication plan
Notfalldatenmanagement (NFDM) 2017 [Emergency data management] [22,24]	Measures for the introduction of emergency data management
E-Patientenakte (ePA) 2018 [Electronic Patient Record] [22,24]	Introduction of Electronic Patient Record
E-Patientenfach (ePF) 2018 [Electronic Patient Folder] [22,24]	Introduction of Individual Patient electronic Folder
Präventionsgesetz (PrävG 2015) [Prevention Act 2015][25]	Law document on a joint national prevention strategy, including initiatives implemented to reduce health inequalities
Amendment of 'Fernbehandlungsverbot' (Muster-)Berufsordnung (MBO-Ä) § 7 Abs. 4 MBO-Ä (2019) [Relaxation of Long distance treatment ban 2019][26]	Relaxation of prevailing professional prohibition of exclusive long-term treatment
Terminservice und Versorgungsgesetz (TSVG 2019) [Appointment Service and Supply Act 2019][27]	Law promoting legally insured patients to get faster appointments with a doctor
Digitale Versorgung Gesetz (DVG 2019) [Digital Supply Act 2019][28]	Law for better supply through digitization and innovation

Table 4. Retrieved documents pertaining to regulation of digital health, including software as a medical device in the US.

Title and Year	Type and Key Normative Content
Software Precertification Program: Regulatory Framework for Conducting the Pilot Program within current authorities (2019)[29]	FDA guidance document detailing the regulatory working model and pathway for De Novo-eligible SaMD and test plan in the software precertification program
Proposed Regulatory Framework for Modifications to Artificial Intelligence / Machine learning - Based Software as a Medical Device (SaMD) (2019)[30]	FDA guidance document examining inherent features and use of AI in healthcare; Types of AI-based SaMD; Regulatory approach to total product lifecycle for AI-based SaMD
Off-The-Shelf Software Use in Medical Devices (2019)[31]	FDA guidance document detailing the premarket submission of off-the-shelf software; Also details needs and responsibilities of the manufacturer
Medical Device Data Systems, Medical Image Storage Devices, and Medical Image Communications Devices (2019)[32]	FDA guidance document detailing the identification of medical device data systems, medical image storage devices and medical image communication devices that the FDA will not enforce regulatory controls
Clinical and Patient Decision Support Software (2019)[33]	FDA guidance document detailing the regulatory oversight of CDSS intended for healthcare professionals and patient decision support software intended for patients, care givers
Policy for Device Software Functions and Mobile Medical Applications (2019)[34]	FDA guidance document mapping FDA's oversight approach to software and mobile medical applications
State Telehealth laws and reimbursement policies (2018)[35]	US report showing state-wise telehealth services and reimbursement policies
Medical Device Cybersecurity Act of 2017 (2017)[36]	Document with recommendations for monitoring, identification, addressing cybersecurity vulnerabilities and exploits in the post-market management of medical devices
Deciding When to Submit a 510(k) for a Software Change to an Existing Device FDA Guidance Document (2017)[37]	Guidelines for determining when a software change to a medical device requires FDA clearance
21st Century Cures Act (2016) with subsequent amendment to the Federal Food, Drug, and Cosmetic Act (2017)[38,39]	Definition of medical device with indications on the classification of software
General Wellness: Policy for Low Risk Devices (2016)[40]	FDA guidance document with details of software categorized as a low risk device

Table 5. Retrieved documents for the general regulation of digital health and software as a medical device.

Title and Year	Type and Key Normative Content
Software as a Medical Device (SaMD): Clinical Evaluation (IMDRF) (2017)[41]	Guidance document for individual jurisdiction to adopt a regulatory framework to making clinically meaningful SaMD
Guidelines on the Qualification and Classification of Standalone software used in healthcare within the framework of Medical Devices (MEDDEV) (2016)[42]	EC guidance document on the legislation and classification for standalone health care software with examples.
Software as a Medical Device (SaMD): Application of Quality Management System (IMDRF) (2015)[43]	Guidance document with explanation of the quality management system; Risk management for SaMD.
"Software as a Medical Device": Possible Framework for Risk Categorisation and Corresponding Considerations (IMDRF) (2014)[44]	Guidance document with explanation of the categorisation of SaMD based on risk; Examples of SaMD showing the application of the risk categorisation framework

Table 6. Analysis of selected documents.

Title	Strengths	Weaknesses / Other Comments
Software as a Medical Device (SaMD) - IMDRF (2014-2017)[41,43,44]	Lays foundation for definition, categorisation, clinical validation of SaMD; Examples of SaMD provided; Advocates post-market surveillance & good software practices	Categorisation does not cover clinical effectiveness effectively; Does not address multifunctionality
Guidelines on Qualification and Classification of Standalone software within the framework of Medical Devices (2016)[42]	Provides a decision diagram for qualification of software as a medical device; Classification criteria not solely on risk	Looks simply at manufacturer's stated intended purpose; Needs to be updated according to MDR and IVDR
Manual on Borderline and Classification in the Community-Regulatory Framework for Medical Devices (2019)[5]	Highlights borderline cases and assists manufacturers to classify devices as medical devices or not and the reason for distinction	Includes limited, uncategorised software and mobile applications
ePrivacy Regulation (2019)[6,7]	Complements GDPR on electronic communication data relating to personal data (consent to cookies and opt-outs) in cross-border communications, processing activities	Ambiguity on processing of personal data based on legitimate interests of the controller
Legal and Regulatory implications of Artificial Intelligence (2019)[8]	Assessment of legal and regulatory implications of AI and mHealth on data protection, intellectual property, cloud computing services, medical devices and liability	Raises pertinent issues, however no recommendations or proposals provided; No clarity of mHealth categorisation; Liability in AI absent
Proposed Guiding Principles for Reimbursement of Digital Health Products and Solutions (2019)[9]	Details key principles of reimbursement for digital health products with recommendations for each of the principles	Excludes lifestyle apps, devices that are not marked with CE
Liability for emerging digital technologies (2018)[10]	Provides an overview of liability for AI	AI in healthcare is not adequately covered
Regulation (EU) 2018/1807 concerning the framework for the free flow of non-personal data[11]	Allows storage, processing of non-personal and anonymised data without unjustified restrictions; Guides processing of datasets with personal and non-personal elements	Mixed datasets prevent the free flow of non-personal element of data as these are subjected to GDPR
Regulations (EU) 2017/745 and 2017/746 on Medical Devices and Invitro medical devices[12,13]	Provides clarification of the classification of software, establishment of a wider EUDAMED database, introduces unique device identification (UDI)	Up-regulates software classification through Rule 11 (Appendix 4); Ignores the term 'standalone software'
Big Data: A complex and evolving regulatory framework (2017)[14]	EU guidelines to make full use of data in concert with data protection laws, establishment of credibility, trustworthiness and potential of pan European' data lakes'	No mention of liability; Key features of AI in the context of acquiring data not adequately addressed
Regulation (EU) 2016/679 – GDPR[15]	Strengthens data protection of EU citizens; Strong value to consent	Provides an exemption for use of data in research
EU guidelines on assessment of the reliability of mobile health applications (2016)[16]	Highlights nine criteria -credibility, effectiveness, transparency, reliability, accessibility, desirability, safety, stability, security, usability for assessing the reliability of mHealth for mHealth apps that are not considered medical devices	Identifies certain gaps in regulation, but does not provide practical recommendations; Does not mention the regulation of mobile platforms
mHealth sub-group Report on national mHealth strategies (2016)[17]	Information with case examples on certification and endorsement of mHealth applications	Framework for certification/endorsement of mHealth apps not discussed nor provided
Green Paper and Summary Report of the responses on the Green Paper on Mobile Health (2014-2015)[18,19]	Presents wide ranging issues in mHealth, while presenting solutions, recommendations, actions and specific measures	-
Existing EU legal framework applicable to lifestyle and wellbeing apps EC Staff Working Document (2014)[20]	Describes EU legislation applicable to lifestyle and wellbeing apps related to app user's rights and consumer rights	Limited to user rights, certification/endorsement of mHealth, categorisation of apps not provided
Council Directive (85/374/EEC) concerning liability for defective products[21]	Details producer liability, defective products, damage and injury	Does not exclusively mention digital health

Table 6. Analysis of selected documents. (Continued)

Title	Strengths	Weaknesses / Other Comments
Sozialgesetzbuch Fünftes Buch (SGB V Social Code)[22]	Lays the foundation of digital health in the German healthcare system through the Telematik infrastructure and electronic health card	Use of mHealth, reimbursement, liability not adequately addressed
E-Health-Gesetz 2015[22,23,24] [eHealth Act 2015]	Introduction of digital applications to German healthcare system; Telematics infrastructure, Electronic health card-eGK	Successful implementation subject to a robust data protection system
Präventionsgesetz 2015 [Prevention Act 2015][25]	Allows individuals to get reimbursed through their health insurance for preventive activity, holding value to digital health	The text of the act does not particularly mention the use of digital health as a preventative strategy
2019 Amendment of 'Fernbehandlungsverbot' [Relaxation of Long distance treatment ban 2019][26]	Permittance of exclusive counselling or treatment by communication media in individual cases if medically justifiable	Need to formulate the terms of what is allowed in order to prevent misuse
Terminservice und Versorgungsgesetz 2019 [Term Service and Supply Act 2019][27]	Allows arrangement of appointments by phone, online or via app; Doctors are better remunerated	Needs implementation of the electronic patient record which is currently being done
Digitale Versorgung Gesetz 2019 [Digital Supply Act 2019][28]	Endorses prescription for health apps, video sessions, access to secure data network during treatment	Approval of apps, data protection of electronic patient record, concept of rights need assertation
Software Precertification Program (2019)[29]	Details regulatory pathway of the pilot program; Role of FDA as the regulator; Risk categorisation of SaMD	Does not adequately refer to liability in case of untoward incidents
Proposed Regulatory Framework for Modifications to Artificial Intelligence / Machine learning-Based SaMD (2019)[30]	Addresses' locked' & adaptation features of AI systems; Advocates Total Product Life Cycle; Highlights 3 modifications subject to regulation	-
Off-The-Shelf Software Use in Medical Devices (2019)[31]	Exhaustive account of guidelines surrounding use of Off-The-Shelf software	-
Medical Device Data Systems, Medical Image Storage Devices, and Medical Image Communications Devices (2019)[32]	De-regulates functions that are solely intended to transfer, store, convert formats, display medical device data, results	Hardware remains a medical device, but is de-regulated, specialised hardware is not addressed; Ambiguity on multifunctional devices
Clinical and Patient Decision Support Software (2019)[33]	Down-regulation of CDSS software while conforming to risk categorisation	Uses device, non-device concepts equivocally, relies on user ability; Some software classified as devices not subject to device regulations
Policy on Mobile Medical Applications (2019)[34]	Oversight based on risk and functionality; Exercises enforcement discretion over lower risk functions	Does not address multifunctional apps
State Telehealth laws and reimbursement policies (2018)[35]	Removes significant barriers to the coverage of reimbursement policies	Challenges in nationwide implementation
Medical Device Cybersecurity Act of 2017 (2017)[36]	Advocates remote access protection for medical devices; FDA recertification for fixes not required	-
Deciding When to Submit a 510(k) for a Software Change to an Existing Device FDA Guidance Document (2017)[37]	Identifies software modifications that require reapproval in terms of safety, effectiveness and intended use; Defines terms of modifications	Does not address software that is under regulatory enforcement discretion
21st Century Cures Act (2016) & subsequent amendment of the Federal Food, Drug, and Cosmetic Act (2017)[38,39]	Main law governing medical devices; Amendments to exclude decision support software from being defined as medical devices	Functions mentioned for decision support systems could also apply to standalone software
General Wellness: Policy for Low Risk Devices (2016)[40]	Categorisation of Low Risk devices for general wellness	Determination of risk not adequate

The experts stated the need for agencies to provide guidelines on "sensible medical applications," i.e. applications that provide a benefit to the user. The difficulties in regulating mHealth applications stem from the fact that there is no organisation to test or rate all mHealth applications available today. Secondly, it is difficult to differentiate applications for medical purpose from those meant for entertainment. It is also difficult to control the release of applications, since the placement of restrictions are not effective. In order to regulate applications on mobile platforms, the following was suggested: a system based on the purposiveness of apps, rating of applications provided by users' experience, placement of disclaimers and guidelines to allow people to be aware of the good use of the application and a system reflecting the literacy and frailty of the user.

The informants stated that the use of risk to classify medical devices is most important. Medical devices circulate around the world, and hence they should be exchangeable. A classification system based on similar parameters is required in order to stay on a global level. However, this system is a type of preventive evaluation and is not oriented to the needs of the patient. It only reflects the efficacy of the medical device and not its effectiveness and thus lacks the ability to look at effectiveness on the quality of life. On the possibility of classifying medical devices on factors other than risk, the experts suggested systems based on the score of quality of life on using the application and results from users.

Medical technology moves faster than regulation, and hence legislation is inadvertently delayed. With a myriad of new technologies, it is necessary to apply new approaches, ideas and tools to evaluate and assess their efficacy. There is a need to ascertain the value afforded to a patient by a clinical decision support system taking into account the literacy and frailty of the user. A single, random medical decision support for everyone is inappropriate. The framework for artificial intelligence-based medical devices is covered by the medical device regulation. The experts noted that the current legal framework is insufficient and only in place to progress with the technology, thus restricting the emergence of new technologies. Other challenges include corporate interests and ethical considerations.

There must be a clear distinction between digital health uses and entertainment purposes. One main issue with the regulation of telemedicine is liability and jurisdiction. Since current rules do not provide adequate clarity, there is a need for a core of regulations ('who is responsible', 'which regional law must be followed') stating the liability for each field of telemedicine. Recognition and requirements of services, reimbursement of second opinion, exchange of health data and information between the doctor and the patient were considered as issues for the uptake of telemedicine. Picture and broadcasting laws are different from the Internet and thus broadcasting services can be blocked, affecting the access to telemedicine services. There are barriers with full deployment of services, related to the right of access, sovereignty and political resistances. Liability in digital health was considered to pertain to 'Doctor to Patient' and 'Doctor to Doctor' and the person closest to the patient should be considered liable. Another consideration was that regulations only focus on prerequisites to place devices on the market, and there is no clear regulation on the conditions under which the devices are being used, which can account for liability.

Discussion

The issues and challenges related to the regulation of digital health are manifold and are related to the rapid growth of biomedical technology with new ways of treatment and diagnosis. The key to a robust legal and regulatory framework is the establishment of trust, expectation, fairness and confidence among users. In order to achieve this objective, a proposed framework for the regulation of digital health must include the key elements of compliance with data security, privacy and protection, the adoption of good practices by developers and regulators along with criteria for the certification of software used as medical devices. The application of reimbursement strategies like the provision of coding for digital health services and the adoption of value-based reimbursement while showing a clear financial advantage for digital health technology is paramount. Finally, clarity on uncertainties in legislation that apply to digital health products and liability in case of jurisdiction for telemedicine services must be included.

As part of the strategy to provide a robust framework for digital health technology, the term 'Meaningful Regulation' of digital health is proposed. In the wake of the digital health boom and the current state of digital health regulation, 'Meaningful Regulation' essentially denotes strong regulation where such regulation is lax enough to support the momentum, but not so liberal so as to jeopardise health and privacy. In essence, the frameworks must neither be risky nor too strict. This is important for countries beginning to develop their legal and regulatory frameworks. As of today, the regulatory frameworks are not as supportive as we require or need them to be. The EU does not appear to be competitive in the digital health landscape. Regulatory authorities must have the right degrees of freedom to advocate for the responsible use of digital technology. Coupled with this aspect, frameworks must be designed that incorporate strategies encouraging entry and use of novel digital technology. Emerging technologies like artificial intelligence and the use of big data must be rightly encouraged while adhering to the basic requirements like privacy and data protection laws and at the same time instilling an element of trust into users.

Digital health proposes a shift from having a close contact with the physician to an almost invisible contact with the physician. Telemedicine and mobile applications present

good opportunities to allow users to identify their condition and seek appropriate medical attention. Among the challenges posed by the regulation of digital health, of immediate concern are those that are related to telemedicine and the liability for digital health services. Telemedicine has particular opportunities in situations that lack facilities and out-of-reach areas, and therefore there has to be clarity with regard to jurisdiction and wide access to this service. Other challenges in the regulation of digital health include the identification of the needs and attitudes of the healthcare professionals and the need for the educational system to provide them with the necessary knowledge and skills. From an ethical point of view, there is a possibility that technological innovation brings medical practice close to statistics than humanity. Thus, there is a need for consumer organisations that involve a citizen-patient perspective.

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