WORLD JOURNAL OF PHARMACEUTICAL RESEARCH
Coden USA: WJPRAP Impact Factor 8.63
Volume 15, Issue 18, 301-316. Review Article ISSN 2277–7105

U.S. FDA REGULATORY GUIDELINES AND VALIDATION OF DIGITAL THERAPEUTICS

Thota Bhargavi*, M. Beena Devi, M. V. Nagabhushanam, G. Ramakrishna

Department of Pharmaceutical Regulatory Affairs, Hindu College of Pharmacy, Amaravathi Road, Guntur, Andhra Pradesh, India-522002.

Article Received on 12 August 2026,
Article Revised on 02 Sept. 2026,
Article Published on 16 Sept. 2026,

https://doi.org/10.5281/zenodo.22767914

***Corresponding Author**

Thota Bhargavi

Department of Pharmaceutical Regulatory Affairs, Hindu College of Pharmacy, Amaravathi Road, Guntur, Andhra Pradesh, India-522002.

How to cite this Article: Thota Bhargavi*, M. Beena Devi, M. V. Nagabhushanam, G. Ramakrishna (2026). U.S. Fda Regulatory Guidelines And Validation Of Digital Therapeutics. World Journal of Pharmaceutical Research, 15(18), 301–316.

ABSTRACT

Digital therapeutics (DTx) are evidence-based, software-driven interventions intended to prevent, manage, or treat diseases and medical conditions. Their increasing use in mental health, neurological disorders, substance-use disorders, chronic diseases, and behavioral medicine has created a need for regulatory frameworks that address clinical effectiveness, software reliability, cybersecurity, usability, and continuous technological change. In the United States, DTx that meet the statutory definition of a medical device are principally regulated by the U.S. Food and Drug Administration (FDA) within the device software framework. Regulatory requirements depend on intended use, risk, technological characteristics, and device classification, with 510(k) premarket notification, De Novo classification, and Premarket Approval (PMA) representing the major premarket routes. Validation extends beyond conventional software testing and includes software verification and validation, clinical evaluation, human-factors engineering, cybersecurity, risk management, quality management, data integrity, and post-market performance monitoring. The transition to the Quality Management System Regulation (QMSR), effective in 2026, further emphasizes lifecycle quality management and alignment with ISO 13485. Emerging artificial intelligence and machine-learning functions increase the importance of predetermined change control, representative data, bias assessment, and continuous real-world performance monitoring. This review summarizes the U.S. FDA framework applicable to DTx, examines principal validation requirements and representative regulatory case studies, and discusses

challenges associated with software updates, cybersecurity, health equity, evidence generation, and AI-enabled adaptive technologies. A total-product-lifecycle strategy integrating clinical evidence, software engineering, quality management, cybersecurity, usability, and post-market surveillance is essential for safe and effective translation of DTx into routine healthcare.

KEYWORDS: Digital therapeutics; DTx; U.S. FDA; Software as a Medical Device; SaMD; software validation; cybersecurity.

1. INTRODUCTION[1-3]

Digital transformation is changing the delivery of healthcare through mobile technologies, connected devices, cloud computing, wearable sensors, artificial intelligence (AI), and advanced data analytics. Within this broad ecosystem, digital therapeutics (DTx) represent an important therapeutic category because software itself delivers an evidence-based intervention intended to prevent, manage, or treat a disease or medical condition. Unlike general wellness applications, which may provide lifestyle education or motivational support, DTx are developed for a defined medical purpose and generally require scientific and clinical evidence demonstrating safety, effectiveness, and reliable performance.

DTx may be delivered through smartphones, tablets, web platforms, virtual environments, or connected sensor systems. Their clinical applications include substance-use disorders, attention-deficit/hyperactivity disorder (ADHD), insomnia, anxiety and depression, chronic disease management, medication adherence, behavioral modification, and rehabilitation. The scalability of software-based treatment can expand access to care and enable repeated therapeutic interactions outside conventional clinical settings. At the same time, these benefits introduce regulatory challenges because software can change rapidly, depend on external operating systems and cloud services, and create new risks involving cybersecurity, data integrity, algorithmic bias, and user-interface design.

In the United States, the FDA regulates digital health products when their functions meet the statutory definition of a medical device. The attached thesis emphasizes that prescription DTx are commonly considered within the Software as a Medical Device (SaMD) or device software framework and that FDA oversight focuses on clinical evidence, software validation, cybersecurity, usability, and post-market surveillance. The regulatory strategy is therefore driven by intended use, risk to the patient, technological characteristics, and the

availability of an appropriate predicate device rather than by the label 'digital therapeutic' alone.

The purpose of this review is to summarize the U.S. FDA regulatory framework applicable to DTx, explain principal premarket pathways, describe the integrated validation requirements expected for software-based therapeutic products, and discuss clinical evidence, quality management, cybersecurity, human factors, AI-enabled software, and post-market lifecycle control. Representative regulatory case studies are also considered to illustrate how software can function as a therapeutic intervention rather than simply as a monitoring or wellness tool.

2. Digital Therapeutics within the Digital-Health Ecosystem[4,5]

Digital health is an umbrella concept covering mobile health, health information technology, telemedicine, wearable technologies, remote patient monitoring, clinical decision support, AI-enabled software, and other digitally enabled health products. DTx occupy a narrower space within this ecosystem because their core function is therapeutic. A DTx may therefore resemble a software-based treatment program, a game-based intervention, a cognitive behavioral therapy platform, or another digital system that produces a clinically meaningful therapeutic effect through repeated patient interaction.

The relationship between DTx and SaMD is important but should not be treated as complete equivalence. SaMD is a regulatory concept describing software intended for one or more medical purposes that performs those purposes without being part of a hardware medical device. DTx, in contrast, is a therapeutic product concept. Many DTx products fit within the SaMD/device software framework because the software is itself responsible for the medical function, but regulatory determination should always begin with the intended function and statutory device definition.

This distinction also explains why not every mobile medical application is regulated in the same manner. Software intended solely for low-risk general wellness, administrative support, or non-device functions may fall outside active FDA device oversight, whereas software delivering a treatment or directly affecting clinical management may require formal device classification and premarket authorization. Consequently, defining intended use precisely is one of the earliest and most important steps in DTx regulatory development.

3. U.S. FDA Regulatory Framework[6,7]

The FDA regulates medical devices primarily under the Federal Food, Drug, and Cosmetic Act and implementing regulations. Within FDA, the Center for Devices and Radiological Health (CDRH) has the principal responsibility for medical-device oversight, including many software-based medical technologies. The Digital Health Center of Excellence and related CDRH programs have supported policy development, scientific evaluation, and regulatory coordination for software, AI-enabled devices, mobile medical applications, wearables, and other digital-health technologies.

The 21st Century Cures Act clarified that certain software functions are excluded from the statutory device definition, thereby reinforcing a function-specific approach. For DTx developers, this means the regulatory assessment should identify each significant software function, determine whether that function is a device function, and assess the risk associated with failure or incorrect performance. A multi-function software product may contain both regulated and non-regulated functions, but interactions between those functions may still be relevant to safety and performance.

Device classification in the United States is risk based. Class I devices are generally low risk, Class II devices are moderate risk and commonly require general and special controls, and Class III devices are high risk and usually require Premarket Approval. The thesis notes that many DTx products are expected to fall within Class II, although the final classification depends on intended use, patient risk, technological characteristics, and the applicable classification regulation. Novel low- to moderate-risk devices without a predicate may enter through De Novo classification, whereas a legally marketed predicate may support a 510(k) pathway.

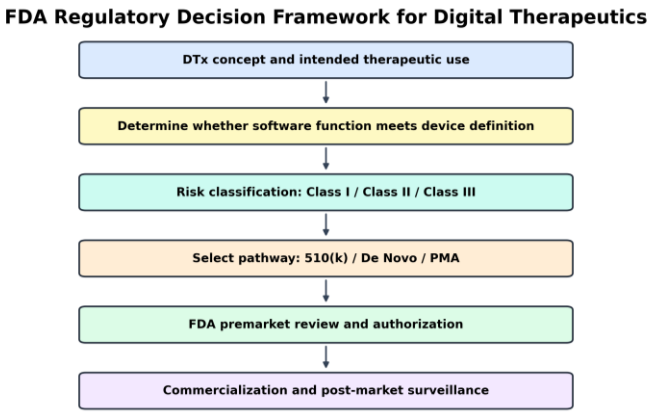

Figure 1: FDA regulatory decision framework for digital therapeutics.

Table 1: Risk classification and typical regulatory implications for DTx.

FDA class	General risk	Typical implication	Relevance to DTx
Class I	Low	General controls; some devices may be exempt from premarket notification	Limited for therapeutic software
Class II	Moderate	General and special controls; 510(k) or De Novo often relevant	Common for many DTx concepts
Class III	High	PMA with extensive evidence	Potentially applicable to selected high-risk functions

4. Principal FDA Premarket Pathways for Digital Therapeutics[8,9]

4.1 510(k) Premarket Notification

The 510(k) pathway is used when a new device can demonstrate substantial equivalence to a legally marketed predicate device. Substantial equivalence requires comparison of intended use and technological characteristics and, when technological differences exist, evidence that those differences do not raise new questions of safety and effectiveness. For a DTx submission, supporting information may include software documentation, architecture, risk analysis, performance testing, cybersecurity information, human-factors evidence, and clinical information when needed. The regulatory outcome is FDA clearance rather than approval.

4.2 De Novo Classification

The De Novo pathway is particularly important for innovative DTx because it provides a route for novel low- to moderate-risk devices for which no legally marketed predicate exists. The applicant must present sufficient evidence to support the safety and effectiveness of the new device type and describe appropriate general and special controls. Once granted, the De Novo request establishes a new classification regulation and can create a predicate for future 510(k) submissions. This pathway therefore combines regulatory flexibility with the establishment of device-specific controls.

4.3 Premarket Approval

PMA is FDA's most stringent premarket pathway and generally applies to Class III devices. It requires valid scientific evidence providing reasonable assurance of safety and effectiveness for the intended use. A high-risk digital therapeutic could therefore require extensive clinical evidence together with comprehensive software, risk-management, cybersecurity, manufacturing, and quality information. PMA is less common for current DTx concepts than

Class II pathways but remains relevant when the therapeutic function carries a high potential risk.

Table 2: Comparison of major FDA premarket pathways relevant to DTx.

Parameter	510(k)	De Novo	PMA
Regulatory principle	Substantial equivalence	Novel device classification	Reasonable assurance of safety and effectiveness
Predicate	Required	Not required	Not required
Typical risk	Low/moderate	Low/moderate	High
Evidence burden	Performance data; clinical evidence as needed	Device-specific safety/effectiveness evidence	Extensive scientific and clinical evidence
Outcome	Clearance	De Novo grant/classification	Approval
DTx relevance	High where predicate exists	High for first-of-a-kind DTx	Selected high-risk products

5. Validation Requirements for Digital Therapeutics[10-12]

Validation is central to DTx regulation because therapeutic software must not only execute code correctly but also perform safely for intended users and produce the claimed clinical benefit. An integrated validation program should begin with user needs and intended use, translate those needs into software requirements, identify hazards, establish traceability, and generate objective evidence through verification, validation, usability, cybersecurity, and clinical evaluation. This lifecycle structure is consistent with the thesis, which identifies software verification, software validation, analytical or clinical validation, human factors, risk management, cybersecurity, and post-market monitoring as interconnected requirements.

A DTx validation strategy should be proportionate to risk. A relatively simple software function may require a focused set of performance tests, while a therapeutic algorithm that directly influences patient treatment may require extensive testing across software, clinical, cybersecurity, and human-factors domains. The evidence package should also identify the released software version, operating environment, interfaces, known anomalies, and configuration controls so that the validated state can be maintained after authorization.

5.1 Software Verification

Software verification answers whether the system was built correctly according to approved specifications. Activities may include requirements review, design review, code review, unit testing, integration testing, system testing, interface testing, boundary and stress testing, error

handling, regression testing, and verification of risk-control measures. Each critical requirement should be linked to one or more verification activities, with documented acceptance criteria and results. A requirements traceability matrix is particularly valuable for demonstrating that user needs, software requirements, identified hazards, risk controls, and verification tests remain connected throughout development.

5.2 Software Validation

Software validation determines whether the finished system satisfies user needs and intended uses under actual or simulated conditions of use. For DTx, this may require testing across supported mobile devices, operating-system versions, browsers, network conditions, cloud interfaces, data inputs, and foreseeable use environments. Validation should evaluate the complete integrated product rather than isolated code modules. It should also confirm that critical therapeutic workflows are robust to interruptions, abnormal inputs, connectivity loss, and foreseeable user errors.

5.3 Analytical and Performance Validation

Analytical or performance validation demonstrates that the software processes inputs accurately and produces reliable outputs. Depending on the DTx function, this may involve algorithm accuracy, reproducibility, data processing, timing, sensor integration, interoperability, decision logic, or calculation performance. For AI-enabled components, performance assessment should use representative and independent datasets and should consider subgroup performance and potential bias.

5.4 Clinical Validation

Clinical validation establishes whether the digital therapeutic produces a meaningful health benefit in the intended patient population. Evidence may arise from randomized controlled trials, observational studies, pilot studies, patient registries, real-world evidence, patient-reported outcomes, and long-term follow-up. RCTs remain highly persuasive for causal assessment, but DTx trials face specific challenges because participants often know whether they are receiving an interactive intervention, adherence may vary substantially, and product updates can occur faster than conventional clinical development cycles.

Clinical protocols should define the intended population, intervention version, comparator, duration, primary and secondary endpoints, clinically meaningful effect size, adherence measurement, missing-data strategy, safety assessments, and statistical analysis plan. Digital

endpoints and biomarkers may provide additional value, but they themselves require adequate validation when used to support effectiveness claims.

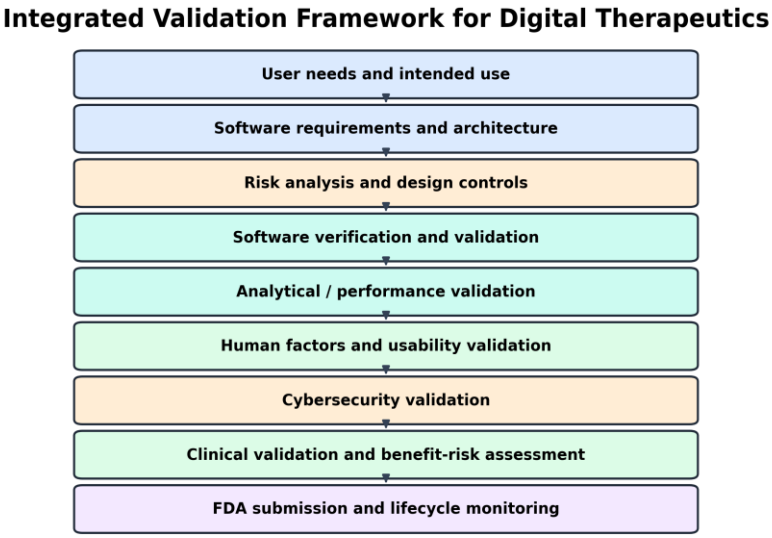

Figure 2: Integrated validation framework for digital therapeutics.

6. Human Factors and Usability Engineering[13,14]

Usability is directly related to safety and effectiveness because many DTx require repeated patient interaction over days or months. Human-factors engineering should define intended users, intended-use environments, critical tasks, foreseeable misuse, and use-related hazards. Formative studies can identify interface problems early, whereas final usability validation should demonstrate that representative users can perform critical tasks safely and effectively under realistic conditions.

DTx usability evaluation should consider age, digital literacy, health literacy, language, disability, cognitive ability, and accessibility. Poor interface design can lead to skipped treatment sessions, incorrect data entry, misunderstanding of therapeutic instructions, or premature discontinuation. Health-equity considerations are therefore not peripheral; they influence whether clinical performance demonstrated in a study can be generalized to the real-world population.

7. Cybersecurity and Data Protection[15-8]

Cybersecurity is a medical-device safety issue because a compromised DTx can expose sensitive information, interrupt therapy, alter data, or affect therapeutic recommendations. A

robust cybersecurity lifecycle should begin during architecture design rather than being added at the end of development. Important activities include threat modeling, asset identification, secure authentication and authorization, encryption, secure communications, secure coding, vulnerability assessment, penetration testing, security logging, patch management, and incident response planning.

Cybersecurity validation should demonstrate that identified controls function as intended and that residual cyber risk is acceptable. Documentation should explain the threat model, security architecture, risk-control measures, known vulnerabilities, testing, update mechanisms, and post-market monitoring. Because vulnerabilities evolve after commercialization, cybersecurity requires continuous surveillance and coordinated remediation. Privacy requirements are related but distinct: privacy governs appropriate collection, use, access, retention, and disclosure of personal information, whereas cybersecurity focuses on protecting systems and data against malicious or unauthorized activity.

8. Risk Management and Quality Management System[19-22]

Risk management provides the organizing structure for integrating software safety, usability, cybersecurity, clinical performance, and change control. Potential hazards include incorrect therapeutic recommendations, software malfunction, data corruption, incorrect patient input, interoperability failure, unauthorized access, cloud-service interruption, and user error. A lifecycle risk-management process should identify hazards, estimate and evaluate risk, implement controls, verify control effectiveness, evaluate residual risk, and monitor new information after commercialization.

Quality management is equally important because DTx are continuously maintained software products. In 2026, FDA's Quality Management System Regulation (QMSR) aligned the U.S. device quality-system framework more closely with ISO 13485:2016. For DTx manufacturers, the practical implication is a stronger lifecycle integration of design and development, risk management, supplier controls, configuration management, verification and validation, complaint handling, corrective and preventive action, and change management. A validated software release should therefore be maintained under formal quality-system and configuration controls.

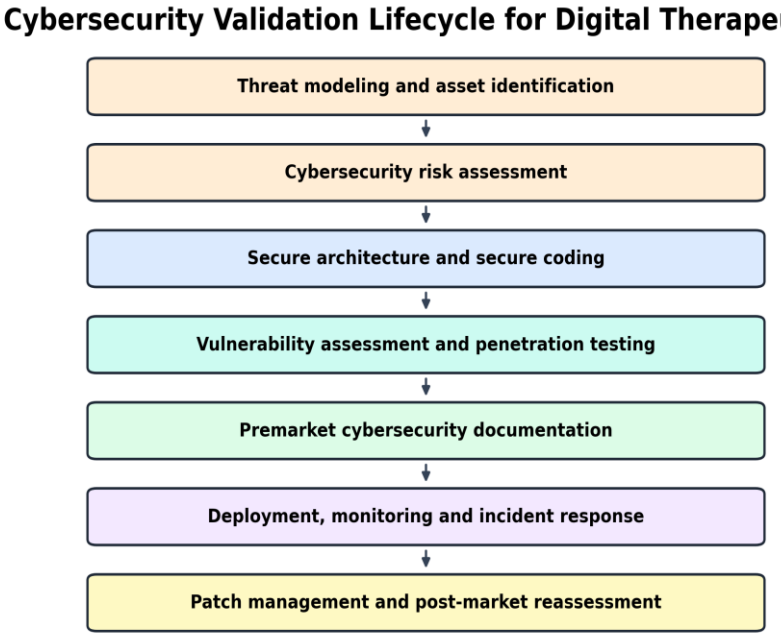

Figure 3: Cybersecurity validation lifecycle for digital therapeutics.

Table 3: Key DTx validation domains and expected evidence.

Validation domain	Primary objective	Representative evidence
Software verification	Confirm requirements are implemented correctly	Test protocols, reports, traceability
Software validation	Confirm intended use and user needs	System validation report
Clinical validation	Demonstrate therapeutic benefit	Clinical study reports, RWE
Human factors	Prevent use-related harm	Usability studies
Cybersecurity	Control cyber risks	Threat model, penetration testing, vulnerability records
Risk management	Maintain acceptable benefit-risk	Risk-management file
Quality management	Maintain controlled lifecycle	QMS procedures, CAPA, change control
Post-market monitoring	Confirm continued safety and performance	Complaints, trends, adverse-event and performance data

9. Artificial Intelligence and Machine Learning in DTx[23]

AI and machine learning can enable personalization, adaptive content, risk prediction, and dynamic treatment recommendations. These capabilities may improve engagement and therapeutic response, but they also create additional regulatory challenges involving dataset quality, representativeness, subgroup performance, bias, algorithm drift, explainability, and modification after authorization. The core regulatory question is not simply whether an

algorithm is accurate at initial release, but whether its performance can remain controlled as data, populations, and software versions change.

A robust AI-enabled DTx development program should characterize training and validation datasets, separate development from independent evaluation, assess performance across relevant demographic and clinical subgroups, document model limitations, and define monitoring for performance degradation. FDA's approach to predetermined change control plans (PCCPs) provides an important mechanism for describing certain planned modifications and the methodology by which they will be developed, validated, and implemented. Such lifecycle planning is especially relevant for software that may be periodically retrained or adjusted after commercialization.

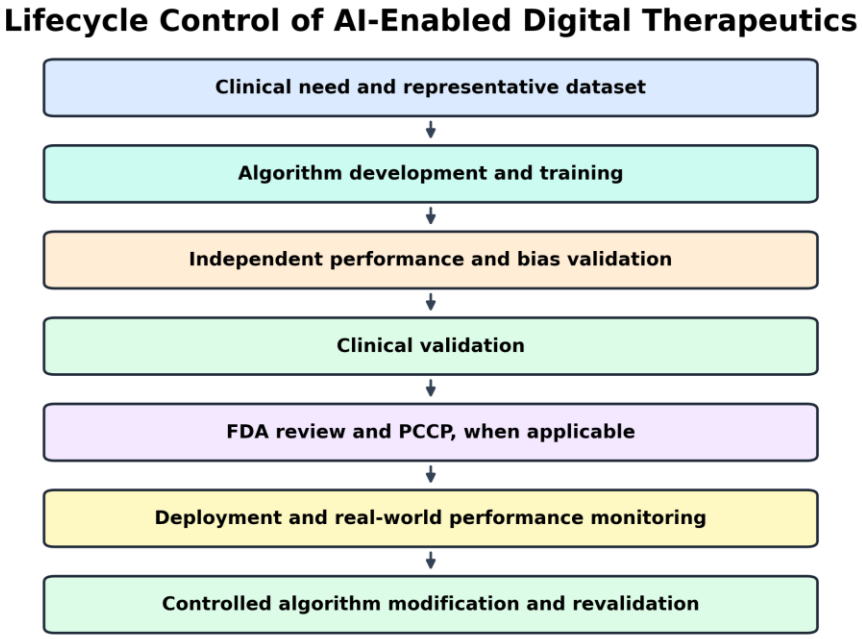

Figure 4. Lifecycle control model for AI-enabled digital therapeutics.

10. Representative Digital Therapeutic Case Studies[24]

The attached thesis uses reSET and EndeavorRx as representative case studies, and these remain useful examples because they demonstrate two distinct therapeutic software models. reSET illustrates prescription software used as part of treatment for substance-use disorder and demonstrates the importance of defined therapeutic claims, clinical evidence, prescription use, and regulatory classification of a first-of-a-kind software intervention. Its broader

significance is that software can itself constitute the therapeutic intervention when the intended use and evidence support that role.

EndeavorRx represents a game-based digital therapeutic for pediatric ADHD. It demonstrates that an interactive digital experience can be developed as a regulated therapeutic product rather than as entertainment or wellness software. From a validation perspective, the product highlights the importance of pediatric usability, engagement, software performance, clinically meaningful endpoints, and lifecycle management. Together, reSET and EndeavorRx show that DTx regulation is technology-neutral: the key issues are intended medical purpose, risk, performance, and evidence rather than the outward appearance of the digital intervention.

11. Post-Market Surveillance and Software Change Management[25]

FDA authorization does not end the validation lifecycle. DTx operate in changing technical environments that include new operating systems, hardware platforms, browsers, cloud infrastructure, third-party libraries, security threats, and user behaviors. Post-market activities should therefore include complaint handling, adverse-event evaluation, Medical Device Reporting when applicable, cybersecurity monitoring, CAPA, real-world performance analysis, version control, and assessment of whether a software modification requires additional regulatory action.

Change control should distinguish routine maintenance from modifications that may alter intended use, performance, safety, or clinical effectiveness. Every significant change should be evaluated for impact on existing verification and validation evidence. Regression testing, risk reassessment, cybersecurity review, usability impact, and clinical implications may need to be considered before deployment. This lifecycle approach is especially important for AI-enabled or cloud-connected software, where changes may occur more frequently than for traditional physical devices.

12. Major Regulatory and Validation Challenges[26]

Rapid technological evolution remains one of the largest challenges in DTx regulation. Conventional premarket frameworks were designed for products that change relatively slowly, whereas software may be updated frequently. Regulators and developers therefore need mechanisms that preserve the validated state while permitting beneficial modifications. Cybersecurity creates a parallel challenge because vulnerabilities may arise long after market entry and may originate from third-party components outside direct manufacturer control.

Evidence generation is also difficult. DTx studies often face high attrition, variable engagement, challenges in blinding, and rapid software iteration. Real-world evidence can complement randomized trials but requires reliable data capture, appropriate comparators, and methods to address confounding. Digital literacy, language, socioeconomic status, disability, and access to compatible technology may also influence both trial participation and real-world effectiveness, creating health-equity concerns.

International harmonization remains incomplete. Differences in device classification, evidence expectations, cybersecurity documentation, software-change management, and quality-system implementation can complicate multinational development. Greater convergence through IMDRF principles, recognized standards, and lifecycle-oriented regulatory science could reduce duplication while preserving patient protection.

13. Future Perspectives[25,26]

The next generation of DTx is likely to become more personalized, connected, and adaptive. AI may tailor therapeutic content according to individual response, wearables and biosensors may provide continuous physiological data, and remote patient monitoring may connect digital interventions more closely with healthcare professionals. Digital biomarkers and patient-generated health data could expand the evidence base for long-term effectiveness and enable earlier detection of treatment failure.

Regulatory science will therefore need to evolve from a predominantly premarket model toward continuous total-product-lifecycle oversight. Predetermined change control, real-world performance monitoring, cybersecurity surveillance, and controlled software updates will become increasingly central. Successful developers will need multidisciplinary teams combining clinical science, regulatory affairs, software engineering, human factors, data science, cybersecurity, quality assurance, and biostatistics.

The most sustainable regulatory model is one in which innovation and control are designed together. Rather than viewing validation as a final testing stage, developers should integrate requirements, risk management, verification, clinical evidence, usability, cybersecurity, and post-market monitoring from the beginning of development. This approach can reduce regulatory uncertainty and provide more durable evidence that the therapeutic benefit remains acceptable throughout the software lifecycle.

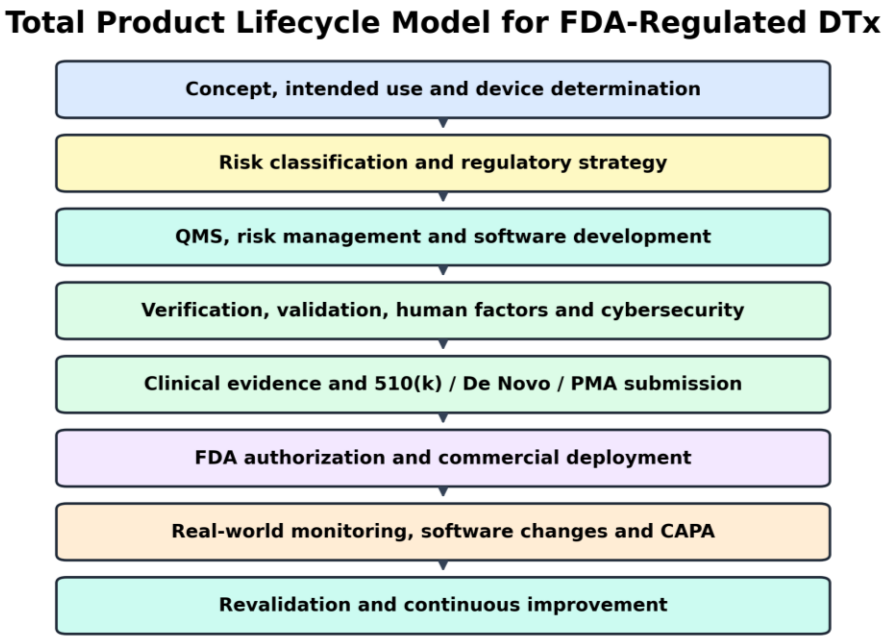

Figure 5: Total product lifecycle model for FDA-regulated digital therapeutics.

14. CONCLUSION

Digital therapeutics represent an important transition from digitally supported healthcare toward software-delivered therapeutic intervention. Their regulation requires a multidisciplinary framework that combines medical-device regulation, software engineering, clinical research, human factors, cybersecurity, risk management, and quality systems. In the United States, regulatory status depends primarily on intended function and patient risk, with 510(k), De Novo, and PMA providing the major device pathways. De Novo is particularly important for novel low- to moderate-risk DTx without an appropriate predicate, while 510(k) becomes relevant when substantial equivalence can be established.

Validation of DTx extends well beyond conventional software testing. A robust program should integrate requirements verification, system validation, analytical and clinical performance, human-factors engineering, cybersecurity, data integrity, risk management, and post-market performance monitoring. The 2026 QMSR further reinforces lifecycle quality management and alignment with ISO 13485. As AI, connected sensors, remote monitoring, and adaptive software become more common, lifecycle change control and real-world monitoring will become even more important. Ultimately, DTx developers should treat regulatory compliance and validation as continuous lifecycle activities rather than one-time premarket documentation exercises.

REFERENCES

1. U.S. Food and Drug Administration. Policy for Device Software Functions and Mobile Medical Applications: Guidance for Industry and Food and Drug Administration Staff. Silver Spring, MD: FDA, 2022.
2. International Medical Device Regulators Forum. Software as a Medical Device (SaMD): Key Definitions. IMDRF/SaMD WG/N10FINAL, 2013; 2013.
3. International Medical Device Regulators Forum. Software as a Medical Device: Possible Framework for Risk Categorization and Corresponding Considerations. IMDRF/SaMD WG/N12FINAL, 2014; 2014.
4. International Medical Device Regulators Forum. Software as a Medical Device (SaMD): Application of Quality Management System. IMDRF/SaMD WG/N23FINAL, 2015; 2015.
5. International Medical Device Regulators Forum. Software as a Medical Device (SaMD): Clinical Evaluation. IMDRF/SaMD WG/N41FINAL, 2017; 2017.
6. U.S. Food and Drug Administration. Device Software Functions Including Mobile Medical Applications. Silver Spring, MD: FDA.
7. U.S. Food and Drug Administration. Clinical Decision Support Software: Guidance for Industry and Food and Drug Administration Staff. Silver Spring, MD: FDA, 2026.
8. U.S. Food and Drug Administration. Cybersecurity in Medical Devices: Quality Management System Considerations and Content of Premarket Submissions. Silver Spring, MD: FDA, 2026.
9. U.S. Food and Drug Administration. Quality Management System Regulation (QMSR). Silver Spring, MD: FDA; effective, 2026.
10. International Organization for Standardization. ISO 13485: 2016 Medical devices - Quality management systems - Requirements for regulatory purposes. Geneva: ISO, 2016.
11. International Organization for Standardization. ISO 14971:2019 Medical devices - Application of risk management to medical devices. Geneva: ISO, 2019.
12. International Electrotechnical Commission. IEC 62304:2006+A1:2015 Medical device software - Software life cycle processes. Geneva: IEC.
13. International Electrotechnical Commission. IEC 62366-1:2015 Medical devices - Application of usability engineering to medical devices. Geneva: IEC.

14. U.S. Food and Drug Administration. Marketing Submission Recommendations for a Predetermined Change Control Plan for Artificial Intelligence-Enabled Device Software Functions. Silver Spring, MD: FDA.
15. U.S. Food and Drug Administration. Predetermined Change Control Plans for Machine Learning-Enabled Medical Devices: Guiding Principles. Silver Spring, MD: FDA.
16. U.S. Food and Drug Administration. Medical Device Software Guidance Navigator. Silver Spring, MD: FDA.
17. U.S. Food and Drug Administration. Digital Health Center of Excellence: Guidances with Digital Health Content. Silver Spring, MD: FDA.
18. U.S. Food and Drug Administration. Recognized Consensus Standards: Medical Devices. Silver Spring, MD: FDA.
19. U.S. Food and Drug Administration. Computer Software Assurance for Production and Quality Management System Software. Silver Spring, MD: FDA.
20. Chung JH, et al. Clinical evaluation approaches for digital therapeutics. 2022. [Verify complete bibliographic details against source thesis before journal submission].
21. Lee U, et al. Data-driven analytics and lifecycle considerations in digital therapeutics. 2022. [Verify complete bibliographic details against source thesis].
22. Odaibo SG. Risk management considerations for AI-enabled Software as a Medical Device. 2021. [Verify complete bibliographic details against source thesis].
23. Nwosu A, et al. Patient engagement and adherence in digital therapeutics for mental health. 2022. [Verify complete bibliographic details against source thesis].
24. Koller C, Blanchard M, Hugle T. Regulatory considerations for digital therapeutics and software-based medical technologies in the United States and Europe, 2025.
25. Brahmaiah Bonthagarala, Lakshmi Prasanthi Nori, Maddala Lohitha, Rama Rao Vadapalli, Venkateswara Raju Kalidindi, Revolutionizing Healthcare: The Impact of AI on Precision Medicine, International Journal of Pharmaceutical Investigation, Apr-Jun, 2025; 15(2).
26. Brahmaiah Bonthagarala, Lakshmi Prasanthi Nori, Jyothirmai Malla, Rama Rao Vadapalli2, Praveen Kumar Dannaram, Kalidindi Venkateswara Raju, Exploring the Healing Paths: Navigating Complementary and Alternative Medicine, International Journal of Pharmaceutical Investigation, Jul-Sep, 2025; 15(3).