Asia-Pacific Journal of Ophthalmology 15 (2026) 100328

Contents lists available at ScienceDirect

Asia-Pacific Journal of Ophthalmology

journal homepage: www.sciencedirect.com/journal/asia-pacific-journal-of-ophthalmology

Global approval and certification of ophthalmic AI devices: A comparative regulatory perspective

Andrzej Grzybowski [a,b,*], T.Y. Alvin Liu [c], Marko M. Popovic [d], Ally Zhao [e], Masahiro Miyake [f], Hidenori Takahashi [g], Ryo Kawasaki [h], Mingguang He [i,j], Xia Gong [i,j], Polat Goktas [k], Kai Jin [l,m]

[a] Department of Ophthalmology, University of Warmia and Mazury, Olsztyn, Poland
[b] Institute for Research in Ophthalmology, Foundation for Ophthalmology Development, Poznan, Poland
[c] Wilmer Eye Institute, Johns Hopkins University, Baltimore, MD, USA
[d] Department of Ophthalmology and Vision Sciences, University of Toronto, Toronto, Canada
[e] Faculty of Medicine, University of Toronto, Toronto, Canada
[f] Department of Ophthalmology, Kyoto University Graduate School of Medicine, Kyoto, Japan
[g] Institute of Medicine., University of Tsukuba, Deep Eye Vision Inc, Japan
[h] Public Health, Department of Social Medicine, Graduate School of Medicine, University of Osaka, Japan
[i] Research Centre for SHARP Vision, The Hong Kong Polytechnic University, Kowloon, Hong Kong Special Administrative Region of China
[j] School of Optometry, The Hong Kong Polytechnic University, Kowloon, Hong Kong Special Administrative Region of China
[k] Faculty of Engineering and Natural Sciences, Sabanci University, Istanbul, Türkiye
[l] Eye Center of Second Affiliated Hospital, School of Medicine, Zhejiang University, Hangzhou, Zhejiang, China
[m] Zhejiang Provincial Key Laboratory of Ophthalmology, Zhejiang Provincial Clinical Research Center for Eye Diseases, Zhejiang Provincial Engineering Institute on Eye Diseases, Hangzhou, Zhejiang, China

ARTICLE INFO

Keywords:
Artificial Intelligence
Ophthalmology
Medical device legislation
Certification

ABSTRACT

Artificial intelligence (AI) tools are rapidly reshaping ophthalmology by improving screening and diagnosis for diabetic retinopathy, age-related macular degeneration, glaucoma, and increasingly retina-based systemic risk assessment. This narrative review provides a comparative assessment of regulatory pathways governing ophthalmic AI and software as a medical device (SaMD) across the United States, European Union, United Kingdom, Australia, China, Japan, Canada, India, and selected emerging jurisdictions. We used a structured search of public regulator databases, guidance documents, manufacturer disclosures, and peer-reviewed literature to assemble a representative sample of marketed or authorized devices through August 2025; the device inventory is illustrative rather than exhaustive. Key differences persist in device classification, evidence expectations, change management for adaptive algorithms, and post-market oversight. Examples such as LumineticsCore, EyeArt, DrNoon for CVD, CLAiR, and EyeWisdom illustrate how risk-based approaches vary across jurisdictions. These inconsistencies can delay multi-region deployment and complicate implementation, supporting the need for lifecycle-focused and internationally aligned standards for safe, transparent, and equitable use of ophthalmic AI.

1. Introduction

1.1. Background

Artificial intelligence (AI) is rapidly transforming ophthalmology; machine learning (ML) algorithms support automated image analysis, disease detection, and risk stratification.[1–3] Ophthalmology is well-suited to AI because it relies heavily on imaging and because ocular structures can be visualized noninvasively.[4] AI tools show high accuracy in identifying diabetic retinopathy (DR), glaucoma, age-related macular degeneration, retinopathy of prematurity, and even some systemic risks inferred from retinal images.[5,6] However, only a limited number of devices have achieved widespread regulatory approval or routine clinical use.[6,7] There is a major opportunity for scalable and cost-effective

* Correspondence to: Department of Ophthalmology, University of Warmia and Mazury, Michała Oczapowskiego 2, Olsztyn, Poland.
E-mail address: ae.grzybowski@gmail.com (A. Grzybowski).

https://doi.org/10.1016/j.apjo.2026.100328
Received 25 March 2026; Received in revised form 5 May 2026; Accepted 5 May 2026
Available online 8 May 2026

ophthalmic care, particularly in resource-limited settings. As AI transitions into clinical workflows, there is a need for robust regulatory oversight to preserve safety, effectiveness, and ethical use.[8]

1.2. The need for harmonization of global regulatory oversight

Regulation of ophthalmic AI remains fragmented. Unlike traditional devices, AI introduces challenges in evaluation, accountability, consent, validation, and lifecycle change management, and these issues are addressed unevenly across jurisdictions.[9–13] The US Food and Drug Administration (FDA), the European Union (EU) CE-marking system under the Medical Device Regulation (MDR), the United Kingdom's MHRA/UKCA framework, Australia's Therapeutic Goods Administration (TGA), China's National Medical Products Administration (NMPA), Japan's Pharmaceuticals and Medical Devices Agency (PMDA), Health Canada, and India's CDSCO all regulate relevant software, but they do so with meaningful differences in evidence requirements, classification, and post-market oversight.[14–16] Recent harmonization efforts include the 2021 FDA/Health Canada/MHRA Good Machine Learning Practice (GMLP) principles and the IMDRF's 2025 final GMLP document. [17,18]

1.3. Study purpose

This study presents a structured narrative review of global regulatory pathways for ophthalmic AI devices, delineating shared principles, points of divergence, and practical gaps. We analyzed key challenges, synthesized ongoing harmonization initiatives, and proposed cross-jurisdictional measures to support responsible international deployment while explicitly acknowledging that public device registries are incomplete and rapidly evolving.

1.4. Scope and methods

This article is presented as a structured narrative review rather than an original registry-based study. We selected jurisdictions with established ophthalmic AI activity or policy relevance (US, EU, UK, Australia, China, Japan, Canada, and India) and added brief contextual discussion of South Korea and Brazil because they illustrate expanding regulatory activity beyond the core comparison set.

To assemble the device tables and regulatory overview, we searched public regulator resources, official guidance documents, manufacturer disclosures when registry detail was limited, and peer-reviewed publications between August 1 and August 15, 2025. Products were included when we identified public evidence of regulatory authorization, certification, or marketed medical-device availability relevant to ophthalmic imaging or retina-based systemic risk assessment. Because public registries are heterogeneous and not uniformly searchable, Tables 1–4 should be interpreted as representative examples rather than exhaustive inventories.

We intentionally retain the device inventory and the jurisdiction-by-jurisdiction regulatory comparison within a single review because the practical interpretation of each framework depends on the types of ophthalmic and retina-based systems that have actually reached authorization or marketed availability.

2. Landscape of AI devices

2.1. Expanding global presence of ophthalmic AI tools

AI integration into ophthalmology is accelerating because imaging workflows, disease definitions, and screening pathways are relatively standardized.[6,19,20] Regulators are increasingly authorizing AI tools for screening, diagnosis, and clinical decision support. These devices differ by intended use, autonomy, and clinical setting. Early ophthalmic benchmarks include LumineticsCore (formerly IDx-DR) and EyeArt,[21–24] while newer systems such as AEYE-DS expanded FDA-cleared autonomous DR screening in 2024 [20,25]. Beyond traditional eye-disease indications, retina-based oculomics tools are also entering regulated markets for systemic risk assessment, including cardiovascular disease prediction from fundus images.[25–28]

2.2. Comparative overview of market approvals

Table 1 provides a representative, non-exhaustive sample of ophthalmic and retina-based AI devices with public evidence of regulatory authorization, certification, or marketed availability across the jurisdictions reviewed. The table is intended to illustrate the diversity of regulatory pathways rather than to serve as a definitive global census. Because public registries differ in transparency and searchability, we triangulated regulator materials with manufacturer disclosures and peer-reviewed publications when necessary. Several systems hold multi-region authorizations, including LumineticsCore, EyeArt, RetinoScan, DrNoon for CVD, and CLAiR.[21,24,26–29]

For clarity, Table 1 includes the South Korean retina-based cardiovascular risk system Reti-CVD / DrNoon for CVD (Mediwhale) as a representative oculomics example.

Where a device addresses cardiovascular risk prediction from retinal images rather than a primary ophthalmic diagnosis, we retained it because it uses ophthalmic imaging workflows and raises closely related SaMD regulatory questions about intended use, validation, and cross-border marketing.

2.3. Implications and need for regulatory alignment

Approval discrepancies increase cost, time-to-market, redundancy, and erode trust, highlighting the need for regulatory harmonization.[10,13,30] An AI considered low-risk in one country may be high-risk in another, requiring redundant validation.[31] Likewise, different countries may apply different standards to similar devices.[32] This fragmentation limits clinical adoption, outcome comparisons, and evaluation of AI "black box"features.[33,34] Thus, there is a need for clear and interoperable regulations, with alignment in definitions, validation, and approval pathways. This alignment sets the stage for a comparative review of regulations (Section 3), the identification of harmonization challenges (Section 4), and potential directions to bridge regulatory gaps (Section 5).

3. Comparative current regulatory frameworks

3.1. United States: U.S. Food and Drug Administration (FDA)

The FDA approaches AI-based Software as a Medical Device (SaMD) regulation using a risk-based model. It has frameworks for evaluating both locked and potentially updated algorithms.[35] Most ophthalmic AI devices are Class II (moderate-risk) products cleared through the 510(k) pathway by demonstrating predicate-device equivalence. While efficient, the 510(k) route may still overlook some AI-specific challenges.[14,36] To support safety and effectiveness, the FDA expects robust clinical validation, including prospective studies where appropriate, such as IDx-DR's pivotal trial of more than 900 patients.[23] Key FDA regulatory criteria include:

- *Clinical performance data (sensitivity, specificity on diverse populations),*
- *Algorithmic explainability and interpretability of outputs,*
- *Cybersecurity and data privacy controls in software,*
- *Post-market surveillance plans (e.g. registries or periodic reporting).*

In 2023, the FDA released draft guidance on Predetermined Change Control Plans for AI devices, allowing certain pre-specified algorithm updates and potentially reducing the need for new submissions after software changes.[20,37,38] The FDA also maintains a public list of AI/ML-enabled devices on the market,[19,39] reflecting a comparatively

Table 1
Representative sample of AI-driven ophthalmology and retina-based oculomics devices with public evidence of regulatory authorization or marketed availability across major jurisdictions.

	Algorithm name	Producer	Country of origin	FDA clearance / authorization	EU CE marking & class	TGA (Australia)	NMPA (China)	Japan (PMDA/ MHLW)	Autonomous	Approved Clinical Conditions
1	IDx-DR	Digital diagnostic	USA	YES	IIa	No data	No data	No data	YES	Diabetic Retinopathy
2	Eyeart	EYENUK	USA	YES	IIa	No data	No data	No data	YES	Diabetic Retinopathy, AMD, Glaucoma
3	Intelligent Retinal Imaging Systems (IRIS)	Intelligen Retinal Imaging Systems	USA	YES	No data	No data	No data	No data	NO	Diabetic Retinopathy
4	Reti-CVD / DrNoon for CVD	Mediwhale	South Korea	No	CE marked	YES	No data	No data	NO	Cardiovascular disease risk prediction
5	Aeye Diagnostic Screening AEYE-DS.	AEYE Health	USA/Israel	YES	No data	No data	No data	No data	YES	Diabetic Retinopathy
6	RetinoScan (TeleEye MD / Rapid DX)	TeleMedC Pty Ltd	Singapore/ Australia	NO	III	YES	No data	No data	NO	Diabetic Retinopathy
7	EyeWisdom	Visionary Intelligence Ltd or Vistel	China	NO	III	No data	YES	No data	NO	Diabetic Retinopathy
8	RetmarkerDR	Retmarker	Portugal	NO	IIa	No data	No data	No data	NO	Diabetic Retinopathy
9	SELENA +	eyRIS	Singapore	NO	IIa	No data	No data	No data	NO	Diabetic Retinopathy
10	Medios AI	Remidio	India	NO	IIa	No data	No data	No data	NO	Diabetic Retinopathy
11	RetCAD	Thirona	Netherlands	NO	IIa	No data	No data	No data	NO	Diabetic Retinopathy
12	OphtAI	Evolucare	France	NO	IIa	No data	No data	No data	NO	Diabetic Retinopathy
13	(COMEN) Aireen DR	Aireen	Czech Republic	NO	IIb	No data	No data	No data	NO	Diabetic Retinopathy
14	DeepDee AI	DeepDee AI	Netherlands/ Belarus	NO	I	No data	No data	No data	NO	Diabetic Retinopathy
15	MONA DR	Mona Health	Belgium	NO	I	No data	No data	No data	NO	Diabetic Retinopathy
16	CARA	Diagnos	Canada	NO	I	No data	No data	No data	NO	Diabetic Retinopathy
17	Retinalyze	RetinaLyze Nordic ApS	Denmark	NO	I	No data	No data	No data	NO	Diabetic Retinopathy
18	Airdoc	Airdoc Technology Inc	China	NO	IIb	No data	YES	No data	NO	Diabetic Retinopathy
19	VUNO Med-Fundus AI	VUNO Inc.	South Korea	NO	IIa	No data	No data	No data	NO	Referable eye disease / multiple retinal abnormalities
20	iPredict	iHealthScreen Inc.	USA	NO	I	No data	No data	No data	NO	Diabetic Retinopathy
21	DeepMind	Google algorithm	USA	NO	No data	No data	No data	No data	NO	Research Only
22	LuxIA/ RetinaAI	RetinaAI	Swiss/Spain	NO	No data	No data	No data	No data	NO	Diabetic Retinopathy
23	retina.help	Brains for Hire	Germany	NO	No data	No data	No data	No data	NO	Diabetic Retinopathy
24	VeriSee DR	Acer	Taiwan	NO	No data	No data	No data	No data	NO	Diabetic Retinopathy
25	Eyetelligence	Eyetelligence Pty Ltd	Australia	NO	No data	YES	No data	No data	NO	Diabetic Retinopathy
26	CLAiR	Toku Eyes	New Zealand/ USA	NO	CE, UKCA	No data	No data	No data	NO	Cardiovascular disease risk assessment
27	CheckEye	CheckEye	Ukraine	NO	No data	No data	No data	No data	NO	Diabetic Retinopathy
28	Recogify	Recogify	Poland	NO	No data	No data	No data	No data	NO	Diabetic Retinopathy
29	RightEye	RightEye Vision System RightEye, LLC	USA	YES	No data	No data	No data	No data	NO	Eye Movement Disorders
30	DeepEyeVision for RetinaStation	DeepEyeVision	Japan	NO	No data	No data	No data	YES (Certification)	NO	Deviation from Normal Fundus

(*continued on next page*)

Table 1 (*continued*)

	Algorithm name	Producer	Country of origin	FDA clearance / authorization	EU CE marking & class	TGA (Australia)	NMPA (China)	Japan (PMDA/ MHLW)	Autonomous	Approved Clinical Conditions
31	DeepEyeVision for California	DeepEyeVision	Japan	NO	No data	No data	No data	YES (Certification)	NO	Appearance (Non-Disease-Specific) Deviation from Normal Fundus Appearance (Non-Disease-Specific)
32	Fundus Image AI Diagnostic Assistance Program RA01	G-DATA	Japan	NO	No data	No data	No data	YES	NO	Normal / Abnormal

FDA Certification (USA): Indicates whether the device has been certified by the FDA in the United States.
CE Mark (EU): Indicates whether the device has received the Conformité Européenne (CE) mark in the European Union.
TGA (Australia): Indicates whether the device is approved by the Therapeutic Goods Administration (TGA) in Australia.
NMPA (China): Indicates whether the device is approved by the National Medical Products Administration (NMPA) in China.
PMDA (Japan): Indicates whether the device is approved by the Pharmaceuticals and Medical Devices Agency (PMDA) in Japan.
EU Device Class: The classification of the device under the EU regulatory framework (Class I, IIa, IIb, III).
Approved Clinical Conditions: Conditions the device is approved to detect or diagnose.
Autonomous: Indicates whether the device operates independently without clinician input.

Table 2
AI-based ophthalmology devices approved by the TGA (Australia).

Device Name	Manufacturer	Intended Use	TGA Classification	Year Approved	Autonomous	Notes
RetinoScan	TeleMedC PTE LTD	Diabetic Retinopathy screening and grading via fundus images	Class IIa	2021	No	Requires clinician review; approved for both diagnosed and undiagnosed diabetes patients
Eyetelligence	Eyetelligence Pty Ltd	Screening microvascular health via retinal image analysis	Class I	2021	No	AI tool with outcomes verified by clinicians; marketed as Software-as-a-Service
iPredict	iHealthScreen Inc.	Early diagnosis of Diabetic Retinopathy, Age-Related Macular Degeneration, and Glaucoma	Class IIa	2022	Yes	Fully automated reports in under 60 s; CE certified and TGA approved
THEIA	THEIA AI	Diabetic Retinopathy and Diabetic Macular Edema detection	Class IIa	2021	No	Achieved 100% sensitivity and high specificity in multi-center prospective evaluation in New Zealand screening program

The TGA's official website for AI-enabled medical devices in the Australian Register of Therapeutic Goods: https://www.tga.gov.au/how-we-regulate/manufacturing/manufacture-medical-device/manufacture-specific-types-medical-devices/artificial-intelligence-ai-and-medical-device-software/ai-enabled-medical-devices-artg

Table 3
AI-based ophthalmology devices approved by the NMPA (China).

Device Name	Manufacturer	Intended Use	NMPA Class	Year Approved	Autonomous	Notes
Airdoc	Airdoc Technology Co., Ltd	Diabetic Retinopathy (DR) screening	Class III	2020	No	First AI retinal screening software approved by NMPA; designed to support clinicians in DR diagnosis.
EyeWisdom	Vistel / Visionary Intelligence	AI-assisted DR detection and classification	Class III	2021	No	Approved as an assistive diagnostic software for DR; intended for use by qualified ophthalmologists.
Zhiyuan Huitu	Zhiyuan Huitu	DR screening	Class III	2021	No	Deep learning (DL) algorithms for DR detection, remote data interaction support.
Silicon Valley Intelligence	Shenzhen Silicon Valley Intelligence	DR screening	Class III	2020	No	Includes USB drive with cloud-based system, supports doctor diagnosis.
Ande Medical	Ande Medical	DR screening	Class III	2020	No	Utilizes DL algorithms, supports remote data interaction.
Beijing Deepwise	Beijing Deepwise Medical	DR screening	Class III	2022	No	AI system for screening DR, designed for primary healthcare settings.
EVisionAI	Yiwei Technology	DR screening	Class II	2020	No	DL algorithms for DR detection, remote data interaction support.
Meilian Medical	Meilian Medical	Fundus Image Diagnosis	Class II	2025	Yes	AI-based fundus camera with diagnostic capability, fully autonomous.

The NMPA's official website: https://www.nmpa.gov.cn/

transparent and adaptive regulatory approach.

3.2. European Union: CE marking under Medical Device Regulation (MDR) and AI Act

The EU regulates medical devices through the CE-marking process under the MDR (European Parliament and Council; Regulation (EU)

Table 4
AI-based ophthalmology devices authorized in Japan (formal PMDA/MHLW approval or certification).

Device Name	Manufacturer	Intended Use	PMDA Class	Year Approved	Autonomous	Notes
DeepEyeVision for Retina Station	DeepEyeVision	Identifying abnormal areas in retinal images	Class II	2021 (certification by a registered certification body)	No	Certification pathway; not formal PMDA approval
DeepEyeVision for California	DeepEyeVision	Identifying retinal non-perfusion areas	Class II	2022 (certification by a registered certification body)	No	Certification pathway; not formal PMDA approval
Fundus Image AI Diagnostic Assistance Program RA01	G-DATA	Normal/abnormal fundus image classification support	Class II	2025	No	Described here as the first formal PMDA approval for an ophthalmic AI SaMD

The PMDA's official website: https://www.pmda.go.jp/english/index.html
DeepEyeVision for Retina Station:
https://www.info.pmda.go.jp/ygo/pack/471857/303ADBZX00110000_A_01_01/
DeepEyeVision for California: https://www.info.pmda.go.jp/ygo/pack/471857/304ADBZX00029000_A_01_01/

2017/745).[40] CE marking is managed by decentralized Notified Bodies designated by EU Member States, which can create variation in implementation and scrutiny.[41] Software intended for diagnosis or screening is generally classified under the MDR as Class IIa (moderate risk) or higher.[24,30] Although historically viewed as more accessible than FDA clearance for some products, the MDR has increased clinical and post-market surveillance requirements.

The EU AI Act entered into force on 1 August 2024 and is being applied in phases rather than awaiting a future start date. Prohibitions and general provisions began to apply on 2 February 2025, the main body of the regime becomes applicable from 2 August 2026, and obligations for high-risk AI embedded in regulated products have a later transition period.[42] Many ophthalmic diagnostic systems will interact with both MDR and AI Act requirements, creating a dual compliance environment, with implementation likely to depend heavily on technical-standard development and conformity assessment practice.[27,43] At the same time, the United Kingdom now operates a separate post-Brexit UKCA pathway and MHRA software/AI change programme, so UK regulatory status should not be assumed from EU CE marking alone.[16,27]

3.3. Australia: Therapeutic Goods Administration (TGA)

Australia's TGA follows a risk-based, IMDRF-aligned system, with software falling into Classes IIa, IIb, or III based on patient risk, and it distinguishes locked from adaptive algorithms.[44,45] For instance, RetinoScan secured Class IIa TGA approval in 2021 but was rated higher risk in the EU.[29,46] The TGA may also rely on foreign approvals, including abridged pathways that reference prior clearance from trusted regulators such as the FDA or CE-marked routes.[46]

At the same time, TGA imposes its own requirements:

- *Human oversight*: Output must not replace clinical decision-making.
- *Transparency*: Labelling must identify AI usage, and instructions, purpose and limitations of the algorithm.
- *Post-market*: Australian Register of Therapeutic Goods (ARTG) registration, incident reporting and additional monitoring for novel AI devices.

Table 2 summarizes key TGA-approved AI ophthalmology devices currently. Overall, the Australian approach recognizes overseas evaluations, while ensuring local accountability.

3.4. China: National Medical Products Administration (NMPA)

China's NMPA treats most AI diagnostic software as Class III (highest risk) medical devices, requiring stringent review for safety and efficacy.[32] As of the August 2025 search window, public summaries indicated that NMPA had approved 126 AI-based medical devices, including eight ophthalmology-focused systems. Many of these target diabetic retinopathy, while companies such as Meilian Medical have also introduced autonomous fundus-camera workflows intended to address China's large diabetic population and shortages of rural ophthalmology services.[47,48] China uses a centralized approval process in which specialized evaluation centers conduct technical assessments before NMPA headquarters grants approval. Building on the framework summarized by Qiu et al. (2025),[49] three notable features of the Chinese regulatory landscape are:

- *Domestic data requirements*: AI must be validated on Chinese populations, with bridging trials for imported systems.
- Fast-evolving guidelines: Emphases on prospective, multi-center validation with transparency and retraining protocols.[50,51]
- Security and privacy checks: Mandatory compliance with cybersecurity law, together with strict privacy and data-localization policies.[32]

The NMPA also pilots real-world, data-based post-market monitoring and mandates cybersecurity testing.[49] However, based on the public sources reviewed for this manuscript through August 2025, we did not identify NMPA-approved ophthalmic AI systems that also held FDA clearance, underscoring the limited overlap across major jurisdictions. Table 3 highlights key AI-based ophthalmic diagnostic tools approved by the NMPA.

3.5. United Kingdom, Canada, India, South Korea, and Brazil: Additional and emerging jurisdictions

The United Kingdom now operates its own medical-device regime outside the EU, although its software and AI as a medical device roadmap remains aligned with broader IMDRF principles.[16] CLAiR (Toku) illustrates the practical importance of this distinction because it obtained CE and UKCA marks in February 2024 for retinal-image-based cardiovascular risk assessment,[27] and the company has also publicly disclosed FDA Breakthrough Device designation for the platform.[28] In Canada, EyeArt received a Medical Device Licence.[52] In India, CDSCO approved Remidio's Medios DR AI in 2024 and Medios HI Glaucoma AI and HI AMD AI in 2025.[53] More broadly, the Indian policy literature continues to emphasize that AI governance, software qualification, and implementation pathways remain active areas of regulatory development rather than a fully settled framework.[28,54–58]

South Korea is also a meaningful comparator because MFDS has approved ophthalmic and retina-based systemic AI devices, including VUNO Med-Fundus AI and DrNoon for CVD.[26,57] Brazil likewise provides a distinct SaMD route through ANVISA's device and software regulations, highlighting that the comparative landscape continues to

expand beyond the core jurisdictions reviewed in detail here.[58]

3.6. Japan: Pharmaceuticals and Medical Devices Agency (PMDA)

In Japan, ophthalmic AI devices may reach the market either through formal PMDA/MHLW approval or, for some Class II products, certification by a registered certification body under the PMD Act. This distinction is important for interpreting chronology and regulatory stringency.

DeepEyeVision for RetinaStation and DeepEyeVision for California appear to have entered the market through certification as Class II devices, whereas G-DATA's RA01 is described here as the first ophthalmic AI device to receive formal PMDA approval in 2025. We revised the text and Table 4 to distinguish certification from formal approval and to avoid implying that RA-100 was the first ophthalmic AI product of any kind available in Japan.

Table 5 provides a side-by-side comparison of the international regulatory frameworks discussed in this review.

4. Challenges in global harmonization

The lack of harmonized standards across regions hinders global adoption of ophthalmic AI because of variations in risk classification, evidence requirements, approval timelines, and post-market oversight.[30] Below, we discuss key challenges to harmonization:

4.1. Divergent regulatory definitions and classifications

Inconsistent definitions and risk classification complicate development and validation and increase redundancy. Regulatory categories depend on intended use, level of autonomy, and clinical context; accordingly, broad statements that one jurisdiction is uniformly more or less stringent than another can be reductionist when applied across device types. An AI tool may be regulated as a medical device in one region but classified differently elsewhere.[59,60] IMDRF has published standardized terminology, but regulators still need greater convergence on AI risk stratification.

4.2. Transparency and explainability requirements

Requirements for transparency differ widely. Transparent reporting should also be anchored to internationally recognized AI-specific reporting standards. In this context, TRIPOD+AI is particularly relevant for studies developing or validating prediction models, while CONSORT-AI is important for clinical trials evaluating AI interventions. Explicit reference to these frameworks can improve the reporting of dataset provenance, annotation procedures, model outputs, human-AI interaction, error analysis, and external validation, thereby enabling clinicians, patients, and regulators to better assess the reliability, safety, and applicability of ophthalmic AI systems across settings.

The FDA and European regulators increasingly expect disclosure of intended use, training data characteristics, performance, and known limitations, although the level of public detail still varies substantially across products.[10,61,62] In contrast, publicly searchable technical information remains limited in several other jurisdictions despite rigorous internal review requirements.[32] A scoping review of 36 regulator-approved ophthalmic AI image analysis devices found persistent evidence gaps, including limited comparative studies and incomplete public performance reporting.[63]

This fragmented regulatory environment makes it difficult for clinicians, purchasers, patients, and regulators to assess foreign AI tools with confidence. Companies often prepare multiple technical and explanatory dossiers for overlapping submissions, and insufficient transparency creates a barrier to independent evaluation.[33,34] Interpretations of explainability also differ: some regulators emphasize human-understandable documentation, whereas others accept relatively opaque models if analytical and clinical performance are adequately demonstrated.[13]

4.3. Data localization and interoperability barriers

Global deployment of ophthalmic AI faces persistent challenges in

Table 5
Comparative overview of international regulatory frameworks for ophthalmic AI devices.

Region	Approval Pathway	AI-Specific Guidance	Clinical Evidence Requirements	Post-Market Obligations	International Harmonization
USA (FDA)	510(k) / De Novo / PMA	Yes - AI/ML Action Plan, change control plan	High - Real-world and clinical validation data	Strong - Performance monitoring required	Moderate - Some convergence with IMDRF
EU (CE/MDR)	Class I-II under MDR via Notified Bodies	Yes - MDR + AI Act	Moderate-High - Varies by Notified Body	Strong - AI Act mandates ongoing oversight	Low-Moderate - Fragmented across Notified Bodies
United Kingdom (MHRA/ UKCA)	UKCA conformity route and MHRA oversight	Yes - Software and AI as a Medical Device Change Programme	Moderate-High - Evidence expectations depend on intended use and device class	Moderate-Strong - Post-market duties under UK medical-device rules	Moderate - Broadly aligned with IMDRF, but distinct from EU CE/MDR
Australia (TGA)	Risk-based SaMD classification aligned with IMDRF	Emerging - Differentiation of locked vs. adaptive AI	Moderate - International bridging accepted	Moderate - Emphasis on human oversight	High - Recognizes FDA/CE approvals
South Korea (MFDS)	Class-based certification/ approval under the Medical Device Act	Yes - Active AI medical-device oversight and guidance	Moderate-High - Clinical and technical evidence required, especially for higher classes	Moderate - Lifecycle oversight with domestic regulatory infrastructure	Moderate - Active contributor to IMDRF, but with domestic implementation pathways
China (NMPA)	Centralized AI-specific review	Yes - Central AI policy framework	High - Localized data required	Strict - Cybersecurity and ethical review	Low - Strong focus on domestic standards
Canada (Health Canada)	Class I-IV MLMD licensing framework	Yes - Draft guidance on adaptive MLMD	Moderate - Clinical performance data required for Class III/IV	Moderate - Change control plan and license updates for ML models	Moderate - Aligned with IMDRF principles
India (CDSCO)	Form 41/CDSCO device registration (State FDA support)	Emerging - AI-based CDSCO approvals, lacking formal AI-specific guidance	Moderate - Multi-center prospective studies for national approvals	Moderate - Varies by state; CDSCO lacks consistent post-market surveillance	Low - National-focused pathway with minimal global harmonization
Brazil (ANVISA)	Notification/registration under RDC 751/2022 and SaMD rule RDC 657/2022	Yes - Specific SaMD instructions within the medical-device framework	Moderate - Clinical evidence scales with risk class	Moderate - Standard device vigilance and lifecycle obligations	Moderate - Uses a distinct national route with increasing international convergence
Japan (PMDA)	PMDA/MHLW approval or certification depending on class	Yes - Formal SaMD guidance with ophthalmic AI precedent	High - Domestic trials or bridging often expected	Strict - Ongoing evaluation and approval audits	Low-Moderate - Progressing with IMDRF, though domestic standards remain stringent

Key References: Abràmoff et al., 2018[23].

data governance and interoperability. For example, China and India may require domestic handling of medical data because of privacy and sovereignty concerns, which can complicate cross-border deployment.[64] In parallel, regulators still lack consensus on endpoints, thresholds, and disease definitions. There are no unified international requirements for mandatory endpoints or reporting formats, which makes direct comparison of AI devices across jurisdictions more difficult.[65]

4.4. Ethical, legal, and cultural divergence

Regional values also differ in how AI is integrated into care. The EU tends to emphasize oversight, privacy, and fundamental rights, while the US often places greater weight on effectiveness and market access.[66] These differences can produce divergent policy choices; for example, autonomous AI may help address physician shortages in one setting yet face tighter constraints in another.[67] Liability rules, consent practices, and patient trust also vary across regions.[10,12,13,66] Even basic disclosure expectations are handled inconsistently. Multinational bodies have proposed common ethical principles,[67,68] but implementation remains jurisdiction-specific.

5. Future directions: toward international alignment in ophthalmic AI regulation

Although individual systems handle local risks in ophthalmic AI regulation, harmonized pathways are needed. Below are steps towards more unified oversight.

5.1. Strengthening international collaboration

National regulatory authorities must collaborate, and initiatives such as the IMDRF help foster dialogue on AI devices.[60] Regulator working groups and mutual-recognition arrangements may reduce redundant effort through structured information sharing.[32] In addition, global forums such as the IMDRF, WHO, and International Telecommunication Union should continue expanding coordination mechanisms to reduce inconsistency while supporting safe innovation.[67–69] Fig. 1 presents selected international regulatory milestones from 2018 to 2025, illustrating rapid policy evolution and the current points of convergence and divergence.

5.2. Standardization of evaluation criteria and evidence requirements

Common standards for AI validation and what constitutes robust evidence are essential because international regulators often differ in metrics and design requirements. In addition, regulatory convergence should place greater emphasis on the generalizability of AI tools. Strong performance in a single dataset or health system does not guarantee safe and effective deployment across different populations, imaging devices, care pathways, and disease prevalence settings. Therefore, evidence requirements should explicitly include external validation across geographically, demographically, and technically diverse cohorts. Another essential but often underreported issue is the quality of image annotation used for training and validation. Because ophthalmic AI performance is highly sensitive to label quality, regulatory submissions should clearly describe annotator qualifications, annotation protocols, adjudication procedures, reference standards, and inter-grader agreement. High-quality and clinically meaningful annotation is fundamental to building trustworthy AI systems. Shared benchmark datasets, agreed minimum performance thresholds, and common study protocols could streamline global evaluation.[23,65]

At the same time, publicly available data on approval timelines, regulatory costs, success rates, and post-market outcomes are not reported consistently enough across jurisdictions to support a defensible quantitative cross-country comparison in this review. We therefore treat these issues qualitatively and identify them as priorities for future empirical regulatory science.

A broader living scoping review of all regulator databases would also be valuable, but it would require a different methodology and update cadence than the comparative policy analysis undertaken here.

Key areas for standardization include:

- *Dataset quality criteria: Common guidelines on dataset representativeness and image quality.*[20]
- *Performance metrics: Clear definitions of which statistical metrics matter, together with checklists to standardize reporting.*[70–72]

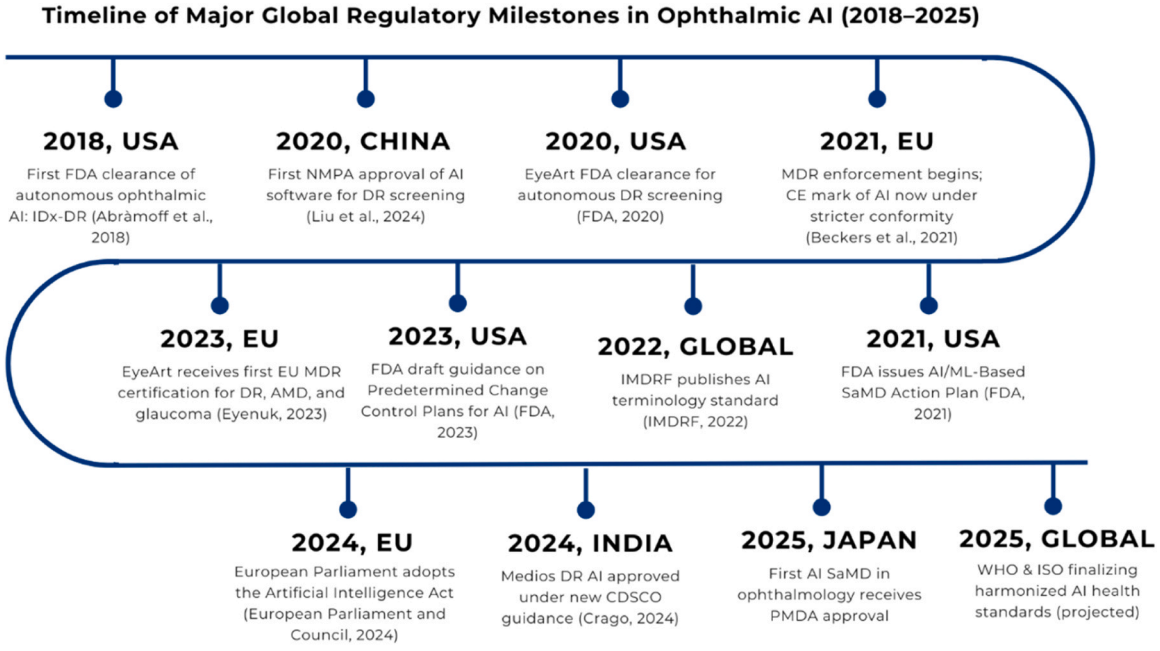

Fig. 1. Timeline of key regulatory milestones in artificial intelligence (2018–2025), highlighting major events such as FDA's first ophthalmic AI clearance (2018), EU MDR implementation (2021), NMPA's first AI approval (2020), the FDA AI/ML Action Plan (2021), the EU AI Act entering into force (2024), and Japan's first formal PMDA approval of an ophthalmic AI SaMD (2025).

- *External validation and post-market monitoring: External validation on new datasets/populations, and post-market monitoring protocols.*[14]

Various international organizations are developing standardized frameworks, and ophthalmic-specific input is paramount (ISO 23894 draft for AI in health) (ISO/IEC 23894:2023, 2023).[73]

5.3. Enabling ethical governance and patient-centered design

Public trust in ophthalmic AI depends on core ethical values at every stage.[74] Frameworks such as FUTURE-AI can be adapted as pre-approval and lifecycle governance checklists.[75] Ethics, transparency on limitations, and responsibility for outputs are needed in liability frameworks to support unified governance. From a patient's perspective, key considerations include:

- *Disclosure and consent:Standardizing informed consent for AI in patient.*[76]
- *Bias and equity:Diverse, shared development datasets and ongoing updates.*[74]
- *Accountability: Clear legal responsibility and guidance on standard of care with AI.*

Championing ethics, transparency and patient-centred approaches can foster public trust and increase consumer uptake.[13] International bodies and professional societies can share best ethical practices and education on the use of AI to patients and clinicians. Through doing so, AI technology can align with international public values.

Human oversight must remain a core safeguard in the clinical deployment of ophthalmic AI. Even when systems demonstrate high diagnostic performance, AI outputs should support rather than replace clinician judgment, particularly in cases involving poor-quality images, atypical presentations, out-of-distribution data, or decisions with significant therapeutic consequences. Clear escalation pathways, user training, and explicit guidance on when specialist review is required are essential to preserve accountability, patient safety, and public trust.

5.4. Building regulatory capacity in emerging markets

Global harmonization must include countries with limited AI regulation infrastructure, because ophthalmic AI can help underserved regions. Key strategies include:

- *Capacity-building programs*: Expert-led training for regulators in developing markets.
- Open-access regulatory toolkits: Ensuring open-access templates, checklists, and testing protocols tailored for countries with limited resources.[74]
- Knowledge-sharing networks: Regional and neighboring networks to discuss AI advances and regulatory practice.[64]
- *Inclusive standard-setting*: Including input from LMIC regulators/clinicians.

Without inclusive regulations, low-quality AI could flood less regulated markets and undermine trust.[64]

6. Conclusion

This structured narrative review shows that ophthalmic AI regulation is progressing rapidly but unevenly across jurisdictions. Differences in definitions, evidence expectations, change-management rules, and transparency obligations continue to complicate global deployment. The comparison also argues against overly simple rankings of jurisdictions as uniformly more or less stringent, because regulatory burden depends strongly on intended use, device class, and local implementation. Since public registries are incomplete and policies continue to change, the device tables should be interpreted as representative snapshots rather than exhaustive inventories. International alignment will require shared attention to generalizability, high-quality annotation, transparent reporting, human oversight, and post-market lifecycle governance.

References

1. Jin K, Yuan L, Wu H, Grzybowski A, Ye J. Exploring large language model for next generation of artificial intelligence in ophthalmology. *Front Med (Lausanne)*. 2023; 10, 1291404. https://doi.org/10.3389/fmed.2023.1291404.
2. Grzybowski A, Singhanetr P, Nanegrungsunk O, Ruamviboonsuk P. Artificial intelligence for diabetic retinopathy screening using color retinal photographs: from development to deployment. *Ophthalmol Ther*. 2023;12(3):1419–1437. https://doi.org/10.1007/s40123-023-00631-9.
3. Goktas P, Grzybowski A. Balancing the promises and challenges of artificial intelligence in ophthalmology. *Ophthalmol Ther*. 2024;13(7):1893–1907. https://doi.org/10.1007/s40123-024-01000-4.
4. Santarsiero M, Garasto S, Hildebrand GD. AI telemedicine screening in ophthalmology: health economic considerations. *Lancet Glob Health*. 2023;11(3): e318–e320. https://doi.org/10.1016/S2214-109X(23)00019-5.
5. Li JPO, Liu H, Ting DS, et al. Digital technology, tele-medicine and artificial intelligence in ophthalmology: a global perspective. *Prog Retin Eye Res*. 2021;82, 100900. https://doi.org/10.1016/j.preteyeres.2020.100900.
6. Li H, Cao J, Grzybowski A, Jin K, Lou L, Ye J. Diagnosing systemic disorders with AI algorithms based on ocular images. *Healthc (Basel)*. 2023;11(12):1739. https://doi.org/10.3390/healthcare11121739.
7. González-Gonzalo C, Thee EF, Klaver CCW, et al. Trustworthy AI: closing the gap between development and integration of AI systems in ophthalmic practice. *Prog Retin Eye Res*. 2022;90, 101034. https://doi.org/10.1016/j.preteyeres.2022.101034.
8. Pham TD. Ethical and legal considerations in healthcare AI: innovation and policy for safe and fair use. *R Soc Open Sci*. 2025;12(5), 241873. https://doi.org/10.1098/rsos.241873.
9. Blanckaert J. The "black box"of artificial intelligence in ophthalmology. *Ophthalmol Eur*. 2024;20(8):13.
10. Goktas P. Ethics, transparency, and explainability in generative AI decision-making systems: a comprehensive bibliometric study. *J Decis Syst*. 2024;33:1–29.
11. Onitiu D, Wachter S, Mittelstadt B. How AI challenges the medical device regulation: patient safety, benefits, and intended uses. *J Law Biosci*. 2024;11(1), lsae007. https://doi.org/10.1093/jlb/lsae007.
12. Mennella C, Maniscalco U, De Pietro G, Esposito M. Ethical and regulatory challenges of AI technologies in healthcare: a narrative review. *Heliyon*. 2024;10(4), e26297. https://doi.org/10.1016/j.heliyon.2024.e26297.
13. Goktas P, Grzybowski A. Shaping the future of healthcare: ethical clinical challenges and pathways to trustworthy AI. *J Clin Med*. 2025;14(5):1605. https://doi.org/10.3390/jcm14051605.
14. Benjamens S, Dhunnoo P, Meskó B. The state of artificial intelligence-based FDA-approved medical devices and algorithms: an online database. *NPJ Digit Med*. 2020; 3:118. https://doi.org/10.1038/s41746-020-00324-0.
15. Kulshreshtha A, Bharadwaj MS. The global regulatory landscape for AI/ML-enabled medical devices. Published September 2024. Accessed August 15 *Regul Focus*. 2025. Published September 2024. Accessed August 15.
16. UK Medicines & Healthcare Products Regulatory Agency. Software and AI as a Medical Device Change Programme Roadmap. 2023.
17. International Medical Device Regulators Forum. Good Machine Learning Practice for Medical Device Development: Guiding Principles. Final document. 2025.
18. U.S. Food and Drug Administration, Good Machine Learning Practice for Medical Device Development: Guiding Principles. Published October 27, 2021. Accessed April 21, 2026.
19. Joshi G, Jain A, Araveeti SR, et al. FDA-approved artificial intelligence and machine learning-enabled medical devices: an updated landscape. *Electronics*. 2024;13(3): 498. https://doi.org/10.3390/electronics13030498.
20. Rajesh A., Lee A. AI for diabetic retinopathy screening: where are we in 2025? Retina Specialist. Published 2025. Accessed August 15, 2025.
21. Digital Diagnostics. LumineticsCore: a letter from the CEO. Published 2023. Accessed August 15, 2025.
22. Ikerian AG. *Ikerian receives EU MDR certificate for ophthalmology data platform and AI models*. Published 2024. Accessed August 15. Press release; 2025.
23. Abràmoff MD, Lavin PT, Birch M, Shah N, Folk JC. Pivotal trial of an autonomous AI-based diagnostic system for detection of diabetic retinopathy in primary care. *NPJ Digit Med*. 2018;1:39. https://doi.org/10.1038/s41746-018-0040-6.
24. Eyenuk Inc. Eyenuk secures EU MDR certification for autonomous AI detection of diabetic retinopathy, age-related macular degeneration, and glaucoma. Published 2023. Accessed August 15, 2025.
25. Lee CJ, Rim TH, Kang HG, et al. Pivotal trial of a deep-learning-based retinal biomarker (Reti-CVD) in the prediction of cardiovascular disease: data from CMERC-HI. *J Am Med Inf Assoc*. 2024;31(1):130–138. https://doi.org/10.1093/jamia/ocad199.
26. Mediwhale Dr. Noon C.V.D. Regulatory information page. Accessed April 21, 2026.
27. Toku. Toku obtains CE and UKCA marks for AI cardiovascular risk assessments through the eye. Published February 5, 2024. Accessed April 21, 2026.
28. Toku. FDA grants Breakthrough Device status to Toku's patented cardiovascular risk AI (CLAiR) platform. Published November 2, 2023. Accessed April 21, 2026.
29. Therapeutic Goods Administration. TeleMedC Pty Ltd-Automated Retinopathy Analysis System: annual charge exemption (2023-24). 2023.

30. Grzybowski A, Brona P. Approval and certification of ophthalmic AI devices in the European Union. *Ophthalmol Ther*. 2023;12:633–638. https://doi.org/10.1007/s40123-023-00588-9.
31. Singh RP, Hom GL, Abramoff MD, Campbell JP, Chiang MF. Current challenges and barriers to real-world artificial intelligence adoption. *Transl Vis Sci Technol*. 2020;9(2):45. https://doi.org/10.1167/tvst.9.2.45.
32. Liu Y, Yu W, Dillon T. Regulatory responses and approval status of artificial intelligence medical devices in China. *NPJ Digit Med*. 2024;7:255. https://doi.org/10.1038/s41746-024-01045-7.
33. Henman P. Improving public services using artificial intelligence. *Asia Pac J Public Adm*. 2020;42(4):209–221.
34. Fehr J, Citro B, Malpani R, Lippert C, Madai VI. A trustworthy AI reality-check: lack of transparency of artificial intelligence products in healthcare. *Front Digit Health*. 2024;6, 1267290. https://doi.org/10.3389/fdgth.2024.1267290.
35. U.S. Food and Drug Administration. Artificial Intelligence/Machine Learning (AI/ML)-Based Software as a Medical Device Action Plan. 2021.
36. Tettey F, Parupelli SK, Desai S. A review of biomedical devices: classification, regulatory guidelines, software as a medical device, and cybersecurity. *Biomed Mater Devices*. 2024;2:316–341.
37. US Food and Drug Administration. Predetermined Change Control Plans for Machine Learning-Enabled Medical Devices: Draft Guidance. 2023.
38. Ropes & Gray. Getting smarter: FDA draft guidance on predetermined change control plans for AI/ML devices. Published 2023. Accessed August 15, 2025.
39. Food US, Administration Drug. Marketing Submission Recommendations for a Predetermined Change Control Plan for Artificial Intelligence-Enabled Device Software Functions. *Draft Guid*. 2024.
40. European Parliament. Council of the European Union. Regulation (EU) 2017/745 on medical devices. *J Eur Union*. 2017:1–175. L117.
41. Beckers R, Kwade Z, Zanca F. The EU medical device regulation: implications for artificial intelligence-based medical device software. *Phys Med*. 2021;83:1–8. https://doi.org/10.1016/j.ejmp.2021.01.001.
42. European Commission. AI Act enters into force. Published August 1, 2024. Accessed April 21, 2026.
43. Gornet M, Maxwell W. The European approach to regulating artificial intelligence through technical standards. *Internet Policy Rev*. 2024;13(3):1–27.
44. Fraser AG, Biasin E, Bijnens B, et al. Artificial intelligence in medical device software and high-risk medical devices. *Expert Rev Med Devices*. 2023;20(6):467–491. https://doi.org/10.1080/17434440.2023.2214515.
45. Qualtech. Australia: TGA updates guidance for software-based medical devices. Published 2024. Accessed August 15, 2025.
46. Therapeutic Goods Administration. Australian Register of Therapeutic Goods entry 374576: TeleMedC Pty Ltd-Automated Retinopathy Analysis System. 2021.
47. Ming S, Xie K, Lei X, et al. Evaluation of an AI-based screening system for diabetic retinopathy in China: a real-world study. *Int Ophthalmol*. 2021;41:1291–1299.
48. Huang XM, Yang BF, Zheng WL, et al. Cost-effectiveness of artificial intelligence screening for diabetic retinopathy in rural China. *BMC Health Serv Res*. 2022;22(1):260. https://doi.org/10.1186/s12913-022-07663-5.
49. Qiu Y, Ma W, Wang H, Tham YC, Wong TY. The landscape of medical artificial intelligence in China. *NEJM AI*. 2025;2(7), AIp2401234.
50. China National Medical Products Administration. Clinical Evaluation Guideline on Artificial Intelligence-Assisted Detection Software. 2023.
51. Palma G, Zhao T. China's NMPA: the evolution of medical device regulation. *Regul Aff Prof Soc*. 2022.
52. Balas M, Micieli JA, Wong JCY. Integrating AI with tele-ophthalmology in Canada: a review. *Can J Ophthalmol*. 2025;60(3).
53. Remidio. Remidio receives CDSCO approval for AI tools to detect glaucoma and age-related macular degeneration. Published 2025. Accessed August 15, 2025.
54. Das SK, Dasgupta RK, Roy SD, Shil D. AI in Indian healthcare: from roadmap to reality. *Intell Pharm*. 2024;2(3):329–334.
55. Kapoor N, Sanjana SN, Davalagi SB, Balu PS, Sethia S. AI horizons in Indian healthcare. *Indian J Community Med*. 2024;49(2).
56. Naik S, Reddy B. A framework for governance of artificial intelligence in healthcare in India. *Indian J Med Ethics*. 2025.
57. VUNO. VUNO Med-Fundus AI. Product page. Accessed April 21, 2026.
58. Agencia Nacional de Vigilancia Sanitaria (ANVISA). Medical devices and Software as Medical Device regulation in Brazil. Updated March 21, 2026. Accessed April 21, 2026.
59. Evans NG, Wenner DM, Cohen IG, et al. Emerging ethical considerations for artificial intelligence in ophthalmology. *Ophthalmol Sci*. 2022;2(2), 100141. https://doi.org/10.1016/j.xops.2022.100141.
60. International Medical Device Regulators Forum. Machine Learning-Enabled Medical Devices: Key Terms and Definitions. 2022.
61. European Commission. Proposal for a regulation laying down harmonised rules on artificial intelligence (Artificial Intelligence Act). COM/2021/206 final. 2021.
62. Shneiderman B. Bridging the gap between ethics and practice: guidelines for trustworthy human-centered AI. *ACM Trans Inter Intell Syst*. 2020;10(4):1–31.
63. Ong AY, Taribagil P, Sevgi M, et al. A scoping review of artificial intelligence as a medical device for ophthalmic image analysis. *NPJ Digit Med*. 2025;8(1):323.
64. Crago SM. Remidio receives CDSCO approval in India for Medios DR AI. Published 2024. Accessed August 15 *Mod Retin*. 2025. Published 2024. Accessed August 15.
65. Ting DSW, Pasquale LR, Peng L, et al. Artificial intelligence and deep learning in ophthalmology. *Br J Ophthalmol*. 2020;104(2):167–175. https://doi.org/10.1136/bjophthalmol-2018-313173.
66. Stahl BC. *Artificial Intelligence for a Better Future*. Springer Nature; 2021.
67. Smuha NA. From a race to AI to a race to AI regulation. *Law Innov Technol*. 2021;13(1):57–84.
68. World Health Organization. *Ethics and Governance of Artificial Intelligence for Health*. 2021.
69. Regulatory Affairs Professionals Society. Global regulatory landscape for AI/ML-enabled medical devices. 2022. Accessed August 15, 2025.
70. Liu X, Rivera SC, Moher D, et al. Reporting guidelines for clinical trials evaluating artificial intelligence interventions: CONSORT-AI extension. *Lancet Digit Health*. 2020;2(10):e537–e548.
71. Rivera SC, Liu X, Chan AW, et al. SPIRIT-AI extension: guidelines for clinical trial protocols involving artificial intelligence. *Lancet Digit Health*. 2020;2(10):e549–e560.
72. Martindale AP, Llewellyn CD, De Visser RO, et al. Concordance of randomized controlled trials with CONSORT-AI reporting guidelines. *Nat Commun*. 2024;15(1):1619.
73. ISO/IEC. ISO/IEC 23894:2023-Information technology-Artificial intelligence-Guidance on risk management. 2023.
74. World Health Organization. Ethics and Governance of Artificial Intelligence for Health: Guidance on Large Multimodal Models. 2025.
75. Lekadir K., Osuala R., Gallin C., et al. FUTURE-AI: guiding principles for trustworthy AI in medical imaging. arXiv. 2021;arXiv:2109.09658.
76. Yap A, Wilkinson B, Chen E, et al. Patients' perceptions of artificial intelligence in diabetic eye screening. *Asia Pac J Ophthalmol (Phila)*. 2022;11(3):287–293.