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# Building the world's first truly global medical foundation model



Since 2022, the field of medical artificial intelligence (AI) has begun a shift toward foundation models, machine learning systems that are trained on broad data at scale and are adaptable to a wide range of downstream tasks[1,2]. Medical foundation models are rapidly evolving, driven by the synergy of expanding medical data repositories, advances in neural network architecture (especially transformers), self-supervised learning approaches and computing power. Medical foundation models are capable of performing, or can be adapted to perform, a range of medical tasks with a minimal amount of annotated data. To date, several promising breakthroughs with foundation models have been demonstrated across diverse medical domains, including pathology, radiology and ophthalmology[3–5].

Nevertheless, training robust medical foundation models requires large, diverse and clinically useful representative data[6]. Assembling such datasets remains a major challenge for the research community because of strict data-sharing regulations intended to protect patient privacy and ensure ethical compliance. For these reasons, most existing foundational models are trained on datasets that are geographically and demographically 'narrow' (that is, not globally representative), limiting their generalizability and effectiveness, particularly in under-represented regions and populations[6–8].

Although there have been efforts to broaden the geographic and ethnic diversity of foundation model training datasets, significant gaps and under-representation remain, especially in Southeast Asia, Central Asia, Latin America, Africa and the Middle East[8]. Furthermore, current foundational models remain vulnerable to shifts in data distribution, especially those arising from variations of imaging devices and manufacturers, further hindering model generalizability[7]. These limitations risk perpetuating existing health inequities and highlight the urgent need for global-scale collaboration and innovative, privacy-preserving data-sharing approaches.

To address these challenges, we have established the Global RETFound Consortium, with the aim of developing the first truly global foundational model in medicine. Building upon our earlier work on RETFound[5], the Global RETFound model will be pretrained on an expansive dataset of over 100 million color fundus photographs (CFPs) from the rear of the eye sourced from more than 100 countries, representing a wide spectrum of ethnic, demographic and geographic diversity, as well as variations in retinal imaging devices.

A key innovation of the Global RETFound Consortium is its flexible, two-pronged data-sharing framework, designed to accommodate the varying technical capacities and regulatory requirements of global partners.

The first approach involves synthetic data generation via local fine-tuning of a generative AI model and secure sharing of the model weights. In this approach, institutions will locally fine-tune a generative AI model (such as a stable diffusion model) on their own anonymized CFPs, guided by available metadata such as demographics, and select ocular and systemic disease labels to improve the quality and population representation of the generated synthetic CFPs. This process will be facilitated by a Docker container (Fig. 1a) that includes all the necessary codes and software, as well as guidance on metadata structuring and graphical processing unit (GPU) compatibility. Importantly, no raw patient data will leave the institution, with only the model weights being shared with the central coordination site, ensuring robust data privacy and regulatory compliance.

The second approach involves real data sharing within a secure infrastructure, with appropriate inter-institutional agreements in place. This alternative is designed for collaborators who do not have access to GPU resources or local technical expertise. De-identified CFPs and metadata will be sent directly to a dedicated, secure cloud platform at the central site, where they will be used to fine-tune a generative AI model and generate synthetic CFPs (Fig. 1b). A combination of real and synthetic CFPs from participating institutions will then form part of the pretraining dataset used to develop the Global RETFound model.

Together, these inclusive approaches will enable participation from research groups of all resource levels, allowing us to build a large-scale, diverse and globally representative dataset that balances data diversity and integrity. This cornerstone will support the development of a medical foundational model that is truly global and equitable.

Earlier studies have shown that synthetic datasets, especially those conditioned on demographic metadata, can improve fairness and downstream performance, particularly for under-represented diseases and populations[9,10]. Building on these insights, the Global RETFound model will leverage the scale and diversity of this curated dataset to pretrain using self-supervised learning strategies. The model will encompass a broad spectrum of retinal phenotypes, disease states, retinal imaging modalities, demographics and other population-specific characteristics. Given these features, the Global RETFound model is expected to enhance generalizability across diverse clinical tasks and settings.

Furthermore, the Global RETFound model will be comprehensively evaluated across a wide range of ophthalmic and systemic disease detection, prediction and risk assessment tasks (for example, oculomics), including those for diabetic retinopathy, glaucoma, age-related macular degeneration, cardiovascular diseases, neurodegenerative diseases and diabetic vascular complications. Real CFPs from several datasets (not used for any pretraining) will be used as validations to ensure rigorous evaluation. Importantly, the Global RETFound model will be released under a Creative Commons CC-BY-NC license, making it freely available for non-commercial research. This commitment to openness is intended to accelerate downstream innovation, empowering researchers worldwide to jump-start the development of their own AI models with substantially reduced data and computational resource requirements. By fine-tuning the openly available pretrained Global RETFound model on their own data, researchers can create models tailored to their specific clinical or research needs.

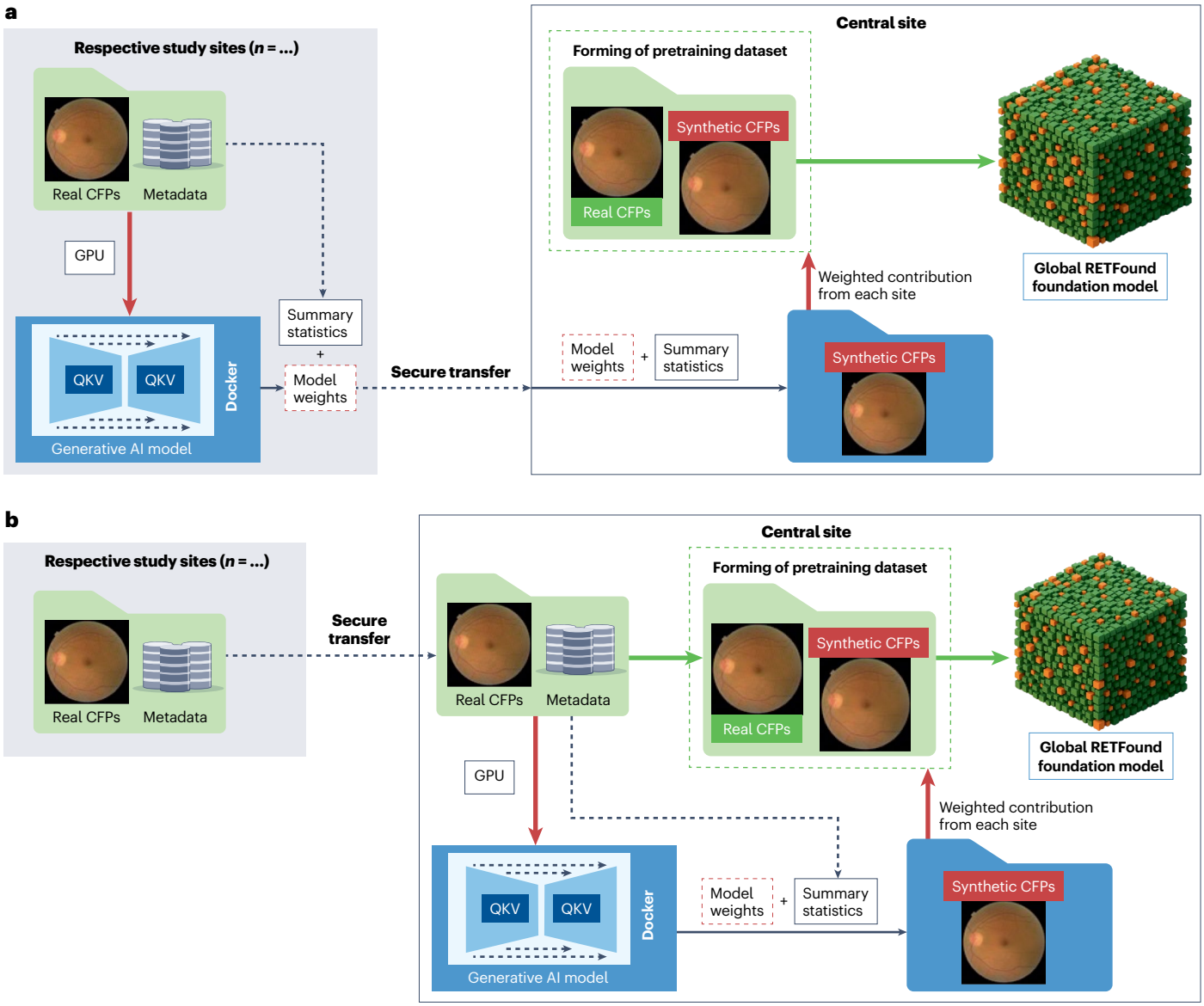


**Fig. 1 | Two-pronged data contribution framework. a**, Generative AI model sharing. In this approach, each study site uses real CFPs and available metadata to locally fine-tune generative AI models. These models are packaged within a Docker container to streamline the fine-tuning process. The outputs (fine-tuned model weights) are securely transferred to the central site, along with summary statistics of the metadata. Using these resources, synthetic CFPs are generated to match the distribution of the original real CFPs. Synthetic CFPs from each site are then combined with real and synthetic CFPs from other sites to form the comprehensive pretraining dataset for Global RETFound. **b**, Real data sharing. In this pathway, each study site securely sends de-identified real CFPs and available metadata directly to the central site. As in **a**, generative AI models are fine-tuned on these real images at the central site to synthesize CFPs that closely match the distribution of the real images. Real and synthetic CFPs from each site, combined with data from other sites, together form the comprehensive pretraining dataset for Global RETFound. Q, K and V refer to query, key and value, respectively.

As of this writing, the consortium has secured collaborations from over 100 study groups across more than 65 countries, spanning Africa, the Middle East, South America, Southeast Asia, the Western Pacific and the Caucasus region. To our knowledge, this initiative marks one of the most geographically inclusive medical AI collaborations to date.

The Global RETFound Consortium represents a landmark international effort to create a truly globally representative medical foundation model, leveraging innovative privacy-preserving strategies through synthetic data generation and secure model weight sharing, and also classical real data contributions. With ophthalmology serving as an initial proof of concept, we aim to share our learnings widely, laying the groundwork for colleagues in other medical fields to adapt and build upon. This global initiative has the potential to establish new international benchmarks for generalizability, fairness and real-world impact in medical AI. We warmly invite researchers and institutions worldwide

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to join this growing collaborative effort and help shape a more inclusive and equitable future for medical AI.

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## Competing interests

C.Y.C. is a cofounder and shareholder of a company (i-Cognitio Sciences) that commercializes retinal imaging based algorithms for brain health assessment. P.A.K. is a cofounder of Cascader, has acted as a consultant for Retina Consultants of America, Roche, Boehringer-Ingelheim and Bitfount and is an equity owner in Big Picture Medical. He has received speaker fees from Zeiss, Thea, Apllis and Roche and travel support from Bayer and Roche. He has attended advisory boards for Topcon, Bayer, Boehringer-Ingelheim and Roche.

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