It takes a planet

To take full advantage of deep-learning solutions in healthcare, the United States and China should collaborate, not compete.

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In an unprecedented move in April, the US government ordered a Chinese artificial intelligence (AI) company, iCarbonX, to divest its majority ownership stake in the Cambridge, Mass.-based company PatientsLikeMe. We believe this action is antithetical to advancing understanding of health and disease, and prevents the potential synergy of US and Chinese strengths. iCarbonX had acquired PatientsLikeMe as part of its efforts to combine data from health records, genomics, the microbiome, wearable biosensors, diet and the environment. Such multimodal data processing is one of the most far-reaching opportunities of AI in healthcare, both for clinicians and patients. Here we argue that the global health benefits of international collaboration, although challenging to actualize, outweigh those of confrontation and competition.

In health AI, sharing data between China and the US could galvanize research and accelerate applications in clinical practice. Credit: Pixtum / iStock / Getty Images Plus / Getty

Health AI from East to West

Recently, a subtype of AI, deep neural networks (DNNs), has come to the forefront of healthcare applications. Remarkable progress has been made in accurate and rapid algorithmic interpretation of medical scans, skin lesions, pathology slides and eye exams, as well as use of DNNs during colonoscopy to pick up small, precancerous polyps[1]. Deep learning and other forms of AI have also been applied to predict clinical outcomes from electronic health records (EHRs), promote patient safety using machine-vision monitoring, process massive datasets from genome sequencing, provide immediate patient-generated data feedback and synthesize notes from patient–doctor visits[1]. In aggregate, there are diverse and exceptional opportunities to improve efficiency, accuracy and workflow in medicine, not to mention improve patient outcomes and lower costs.

This potential progress, however, depends on the availability of carefully annotated data at scale to provide supervised learning for DNNs. China has a major global advantage in terms of scale: it has a population of nearly 1.4 billion and several hospitals (such as Zhengzhou University) with over 10,000 beds each. The magnitude of data has enabled Chinese researchers to carry out some of the first randomized trials demonstrating that DNNs can identify important lesions missed by gastroenterologists during endoscopy and colonoscopy. A Guangzhou Medical University study of EHRs and medical images from over 1.3 million children, with more than 100 million data points, has also shown that AI can improve diagnostic accuracy across most common conditions[2].

China is also forging new ground in applying AI to clinical practice. Guangzhou Second Provincial Hospital has used more than 100,000 of its own EHRs, together with an additional 300 million external EHRs, to widely implement AI tools for prescreening patient symptoms with a chatbot (WeChat), organizing patient data for clinicians and augmenting clinical interpretation of CT scans. There has been extensive uptake of AI for medical image interpretation throughout large hospitals in China, through networks organized by the companies Infervision, Deepwise, Yitu Healthcare and PereDoc and via initiatives at large centers like Zhejiang Provincial People's Hospital. For example, through a collaboration with over 300 hospitals, more than 1 million patient scans amassed by Infervision have been used to train AI algorithms to help diagnose more than 33,000 patients each day. Two companies that provide 'AI doctor' consultations, Ping An Good Doctor and WeDoctor, are connecting with hundreds of thousands of patients every day, and Yidu Cloud is analyzing millions of EHRs to predict optimal treatment and outcomes.

Finally, the Chinese government has made an extensive commitment to support health AI, reflected by billions of dollars of investment and the designation of one of its five national AI labs specifically for clinical applications. China has an articulated goal of becoming the world leader in AI by 2030.

These strengths for health AI in China are counterbalanced by weaknesses. Primarily, transparency is lacking at all political levels, medical research is of lower quality overall, changes to regulatory oversight are slow (albeit with clear improvement recently), and major health outcomes for Chinese citizens are worse than those in the 36 member countries of the Organization for Economic Co-operation and Development (OECD), including the United States.

In comparison, the United States gained a substantial early lead over China in developing AI expertise. For more than a decade, tech titan companies including Google, Amazon, Microsoft and Facebook have been developing and implementing extensive AI algorithms that are central to their businesses. In terms of scale, the country, though not as big as China, is still home to 329 million people—the third-largest population in the world. The overall quality of US research and healthcare remains superior to China, and in the area of education, US computer science students have recently been shown to have greater skills than students in China, India and Russia[3]. The US Food and Drug Administration (FDA), along with its track record in clinical research, has historically been considered the preeminent regulatory authority.

That said, the US population is only a quarter the size of China and its largest academic medical center has only 2,000 hospital beds. To date, no randomized trials testing AI in healthcare have been carried out on US soil. The American AI Initiative announced by the White House in February makes no mention of healthcare or new financial support or resources for medical research. And even though the FDA has cleared or approved several AI algorithms for medical imaging, uptake in clinical practice has been minimal so far (Table 1).

Table 1 | Recent regulatory approvals or clearances for companies with healthcare AI algorithms

Country	Company	Scope
China	Novuseeds MedTech	Machine-vision endoscopy
	QED Technique	Medical imaging
	Huiyihuiying	Medical imaging and radiation therapy
	12 Sigma	Medical diagnosis and multimodal data analytics
	Infervision	Medical imaging
	Deepwise	Medical imaging
	Airdoc	Medical diagnosis and multimodal data analytics
	Yitu Healthcare	Medical imaging
	Dexin Medical	Medical imaging
	Diannei DNA	Medical imaging
	Lepu Medical*	Electrocardiogram diagnosis
United States	Quantib	Medical imaging (MRI)
	CureMetrix	Medical imaging (mammography)
	BrainScope	Concussion assessment (multimodal)
	Apple	Atrial fibrillation detection
	Aidoc	Medical imaging (CT scan)
	iCAD	Medical imaging (mammography)
	Zebra Medical	Medical imaging (CT scan)
	Bay Labs	Medical imaging (echocardiogram)
	Neural Analytics	Device for paramedic stroke diagnosis
	IDx	Diabetic retinopathy diagnosis
	Icometrix	Medical imaging (MRI)
	Imagen	Medical imaging (X-ray)
	Viz.ai	Medical imaging (CT scan)
	Arterys	Medical imaging (MRI and CT scan)
	MaxQ AI	Medical imaging (CT scan)
	AliveCor	Atrial fibrillation detection
	DreaMed	Diabetes treatment decision
	Empatica	Warning of seizure risk
	Subtle Medical	Medical imaging
	Cognoa	Autism diagnosis
	Healthy.io	Urinary tract infection diagnosis
	Excel Medical	Remote monitoring
	FibriCheck	Atrial fibrillation detection
	ScreenPoint Medical	Medical imaging (mammography)
	SyncThink	Eye movement disorders

*China-based company; technology approved by US FDA.

Shared pain points and strengths

Both China and the United States share major pain points in advancing AI in healthcare. First, there are issues with the interoperability of medical data. EHRs are not usually transferable from city to city in China or from one health system to another in the United States, where many communications among hospitals and clinics still take place by fax machine. Second, both countries have problems providing equitable access to healthcare for their rural populations. China has 1.8 doctors per 1,000 people compared with 2.6 per 1,000 in the United States, and there are far fewer primary care doctors in China (only 1 per over 6,000 people).

On the positive side, both countries have extensive AI expertise in industry from big established entities like iFlytek and Ping An in China and Google, Microsoft, Amazon, Apple and IBM in the United States, along with hundreds of startups. There is also a reciprocal presence of many major tech companies in healthcare, such as uptake of IBM's Watson Oncology by many Chinese hospitals and Tencent's AI lab in Seattle. In China, companies like iFlytek are already using natural-language processing of patient–doctor conversations to automate the production of medical office notes; in the United States, many startups and pilot studies are underway in the digital-medicine space. Finally, the regulatory environment in both countries has been supportive of AI medical applications (Table 1), most of which have involved deep learning with medical images.

The case for collaboration

In this context, why the need for continued deep collaboration rather than competition (Table 2)? First and foremost, AI algorithmic development and validation requires diverse and massive datasets. There is little evidence for saturation but plenty of examples of misleading outputs when the data inputs are limited or venue specific. For example, the overemphasis in the genomics research community on studying people of European ancestry has led to gaping holes in our knowledge base. In AI, ancestry substantially impacts algorithmic accuracy—for example, in the interpretation

Table 2 | Pros and cons of deep collaboration by China and the US in AI

China	United States
Pros	
Access to data from 360 million US people	Access to data from up to 1.2 billion people in China
Access to people of multiple ancestries	Access to people predominantly of Asian ancestry
Access to depth of US AI expertise and ability to make up ground in areas where US has a head start	Access to growing Chinese AI expertise, particularly in domains where China has a head start
Harmonization and advance of Chinese regulations to global standards provides greater protections to Chinese citizens and ensures Chinese AI companies access global markets	Chinese regulatory improvements open Chinese market to AI products and services from US companies
Pooling of resources and expertise generates greater insights from AI	Pooling of resources and expertise generates greater insights from AI
Accelerated AI could reduce inequities, increase rural reach and address rare diseases	Accelerated AI could reduce inequities, increase rural reach and address rare diseases
Cons	
Potential access, at least more than at present, to proprietary Chinese AI and breakthroughs and expertise	Chinese AI sector gets even greater access than at present to US proprietary information and expertise, without reciprocity due to lack of Chinese transparency
US track record in commercializing IP means China loses startups that would otherwise have been founded in China	Collaboration exacerbates pirating of US intellectual property and knowledge into Chinese startups
US steals Chinese AI talent	China steals US AI talent
Crossover of AI expertise in health to areas of national economic and military importance	Crossover of AI expertise in health to areas of national economic and military importance
Requirement for resourcing of joint oversight and governance	Requirement for resourcing of joint oversight and governance

of melanoma lesions with different skin colors[4]. Ethnic diversity of input data is essential for better coverage and may lead to more robust AI solutions. Combining data from the United States and China, along with other countries, would help achieve this goal.

A quiet but potentially profound advance in AI methods, federated learning, has made international collaboration more feasible. In this model—also known as distributed or split learning—data are stored and never leave their host health system, clinic or hospital, but machine-learning models are trained from the separate datasets and subsequently combined[4,5]. The use of homomorphic encryption with federated learning could further enhance privacy of the data. Although federated learning relies on standardizing the data to a format that would enable such analytics, this should not be considered an insurmountable issue. Already the French company Owkin is working with various US and European hospitals to develop a federated-learning AI algorithm for cancer patients. Were it not for federated learning, it would be difficult to imagine countries willingly sharing medical data from their citizens.

The power of numbers and diversity built by cooperation between the United States and China could not only drive AI momentum across the globe, but also produce a remarkable infrastructure for nearest-neighbor analysis—a type of AI that matches 'digital twins'[6]. For a person with a particular diagnosis, such a resource would find individuals with similar demographics, clinical data, medical imaging, lab results, omics and other layers of data. That could provide insights about the most effective treatments, such that learning from one another globally could promote the health of all of the planet's inhabitants. Not only would individuals with rare diseases potentially benefit from aggregation of their data; those with serious common diseases that are vexing to treat, like cancer and neurodegenerative conditions, could also be helped. We envision such a platform to be open source, fostering open science and preempting any commercial claims or development based upon its content.

Cooperation between the US and China could also accelerate the creation of a global research and health infrastructure in which harmonized ethical and regulatory standards facilitate sharing of health data and potentiate deep learning. China's entry as a full member to the International Council for Harmonization of Technical Requirements for Pharmaceuticals for Human Use (ICH) reflects its capability and commitment to global biomedical collaboration. Harmonization of key issues, including data security, privacy, rights of data subjects, liabilities and regulatory oversight, would be required to move forward, yet these are not insurmountable challenges. Although the United States and China could be the initiating countries given their interest in AI for medicine, many other countries might be willing to join, either immediately or once the digital infrastructure had been developed. Think of the truly global learning system for healthcare that awaits development.

The case against

There are ample arguments for not pursuing cooperation—or at least reasons why it would be a formidable challenge. Mutual trust is the basis of a meaningful and durable collaboration, but the current political relationship between the two countries is icy and strained.

A key issue is transparency. China has traditionally been a closed society with restrictions on information sharing compared with the United States. This is an immediate impediment to an ambitious AI collaborative effort requiring open science and transparent practices. China also has a documented history of blatant intellectual property theft from the United States and other countries—although as China becomes an increasingly innovation-driven economy, one can expect the balance to shift the other way.

Linked to the issue of transparency is whether collaboration in health AI would spill over into other areas of national interest and geopolitical supremacy. Is it possible to collaborate in the field of healthcare AI and not have sensitive technology spill over into such areas as military operations, space technology, energy, cybersecurity and telecommunications? Currently, there is serious tension between the two countries on trade and tariffs, cyberhacking, intellectual property violations and even alleged breaches of national security.

In the realm of health, maintaining privacy of medical data is another major concern. Protecting the privacy and security of each person's medical data must be considered paramount. Although concerns have been raised about protections for personal medical data in China, Chinese citizens' data are protected and anonymized for any research initiative, and laws covering human genetic data were updated in June.

No major breaches of data have occurred, in part owing to the lack of data consolidation at any regional or national level. This seems like an impressive track record, although it is not possible to verify its veracity from Chinese authorities. Although the perceived higher regard for privacy in the United States and tighter regulations under the Health Insurance Portability and Accountability Act (HIPAA) might seem to be an advantage, there have been extensive data breaches among US health insurers and health systems, numbering over 190 million health records in the past decade—more than 59% of the records for the entire US population.

Conclusions

Given the above concerns, collaboration on AI clearly poses challenges in such sectors as cybersecurity, telecommunications, energy and the military. But medicine is different. Public health does not stop at national borders. It is an area where any country, even countries as big as China and the United States, will find it challenging to achieve the necessary scale of data—from tens to hundreds of millions of humans—to train machine-learning applications that generate robust insights into health and disease. If ever there were a common goal that all countries could embrace, it would be to promote the health of the world's citizens. Bilateral engagement and leadership from the United States and China on planning joint governance and building the infrastructure would be an ideal foundation and test ground for establishing cooperativity (Table 2). Were it not for federated AI learning, our proposition would be unthinkable, given legitimate concerns on patient privacy and transparency. But federated AI offers a clear path for collaboration and acceleration of progress.

Ironically, iCarbonX is one of the first companies in the world to make multimodal AI its priority, with the intent of combining inputs from sensors, genomics, patient-generated data and traditional medical records to provide virtual feedback to clinicians and patients. The Chinese company's acquisition of and partnership with PatientsLikeMe seemed like an ideal testbed for two forward-thinking companies to pursue that objective.

In this context, the forced divestiture of iCarbonX by the United States government is not a savvy protection of US national security interests. The US Committee on Foreign Investment's action is a misguided, myopic fix that will hold back the US AI health sector—as well as the presumed intended target, the Chinese AI health sector. In a flattening world where countries must compete globally for both the best minds and the best technology, AI health is an area where US companies currently lag. Chinese academics and companies already have unfettered access to personal health data. To compete in AI health, US companies will need access to clinical data on a similar scale. How will that be possible if the current isolationist policy continues?

The landscape of medicine has irrevocably changed, with amounts of big data per individual that no human can adequately process. This is occurring at a time when there are unacceptable levels of medical errors, inefficiency, waste, burnout and depression among clinicians and high costs for medical care. Added to that, poor access to medical care among people living in rural areas increases inequities in healthcare. These problems mandate big thinking on how we can pool our resources to promote better health everywhere and for everyone. We have at our fingertips technology capable of analyzing petabytes of data. The difference now is that it is potentially achievable by capitalizing on the ability to analyze the data rather than capitulating to the challenge. Let us embrace this opportunity by working together collaboratively across the planet for the greater good of all. ❐

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Competing interests

E.T. was previously an advisor to Verily Life Sciences and Voxel Cloud, but has resigned from those positions.