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AI diagnostics need attention

Computer algorithms to detect disease show great promise, but they must be developed and applied with care.

One of the biggest — and most lucrative — applications of artificial intelligence (AI) is in health care. And the capacity of AI to diagnose or predict disease risk is developing rapidly. In recent weeks, researchers have unveiled AI models that scan retinal images to predict eye- and cardiovascular-disease risk, and that analyse mammograms to detect breast cancer. Some AI tools have already found their way into clinical practice.

AI diagnostics have the potential to improve the delivery and effectiveness of health care. Many are a triumph for science, representing years of improvements in computing power and the neural networks that underlie deep learning. In this form of AI, computers process hundreds of thousands of labelled disease images, until they can classify the images unaided. In reports, researchers conclude that an algorithm is successful if it can identify a particular condition from such images as effectively as can pathologists and radiologists.

But that alone does not mean the AI diagnostic is ready for the clinic. Many reports are best viewed as analogous to studies showing that a drug kills a pathogen in a Petri dish. Such studies are exciting, but scientific process demands that the methods and materials be described in detail, and that the study is replicated and the drug tested in a progression of studies culminating in large clinical trials. This does not seem to be happening enough in AI diagnostics. Many in the field complain that too many developers are not taking the studies far enough. They are not applying the evidence-based approaches that are established in mature fields, such as drug development.

Many reports of new AI diagnostic tools, for example, go no further than preprints or claims on websites. They haven't undergone peer review, and might never do so. That would verify key details: the underlying algorithm code, and analyses of, for example, the images on which the model is trained, the physicians with which it is compared, the features the neural network used to make decisions, and caveats.

These details matter. For instance, one investigation published last year found that an AI model detected breast cancer in whole slide images better than did 11 pathologists who were allowed assessment times of about one minute per image. However, a pathologist given unlimited time performed as well as AI, and found difficult-to-detect cases more often than the computers (B. E. Bejnordi *et al. J. Am. Med. Assoc.* **318,** 2199–2210; 2017).

Some issues might not appear until the tool is applied. For example, a diagnostic algorithm might incorrectly associate images produced using a particular device with a disease — but only because, during the training process, the clinic using that device saw more people with the disease than did another clinic using a different device.

These problems can be overcome. One way is for doctors who deploy AI diagnostic tools in the clinic to track results and report them, so that retrospective studies expose any deficiencies. Better yet, such tools should be developed rigorously — trained on extensive data and validated in controlled studies that undergo peer review. This is slow and difficult, in part because privacy concerns can make it hard for researchers to access the massive amounts of medical data needed. A News story on page 293 discusses one possible answer: researchers are building blockchain-based systems to encourage patients to securely share information. At present, human oversight will probably prevent weaknesses in AI diagnosis from being a matter of life or death. That is why regulatory bodies, such as the US Food and Drug Administration, allow doctors to pilot technologies classified as low risk.

> ***"Many in the field complain that too many developers are not taking the studies far enough."***

But lack of rigour does carry immediate risks: the hype–fail cycle could discourage others from investing in similar techniques that might be better. Sometimes, in a competitive field such as AI, a well-publicized set of results can be enough to stop rivals from entering the same field.

Slow and careful research is a better approach. Backed by reliable data and robust methods, it may take longer, and will not churn out as many crowd-pleasing announcements. But it could prevent deaths and change lives. ■

Russian research

The sleeping bear of Russian science could finally wake — and China can show it how.

Vladimir Putin will hardly be remembered as a patron of science. Not for Putin the scientific philosophy of dialectical materialism that helped to drive research in the former Soviet Union and that remains influential among many of his contemporaries. His long rule over Russia, as both president and prime minister, shows that he is more inclined to line up with the nation's Orthodox Church. His 2016 choice of an ultra-conservative religious historian as science and education minister was no accident.

But Putin, who is expected to win another six years in power in the Russian presidential elections on 18 March, did not get where he is today without being able to play both sides. He acknowledges — and has often said — that Russia's poor research and development capacity is an obstacle to economic growth and prosperity. His clique of political cronies includes scientists and research administrators. And their lobbying has not been in vain. Russian science spending has palpably (if by no means fully) recovered in recent years from near-collapse in the 1990s.

Outsiders recognize this: international sanctions in response to Russia's occupation of the Crimea have spared East–West research collaboration. And Russia's demanding education system continues to produce a supply of excellent students and scientific talent. Yet, as discussed in a News story on page 297, too many Russian labs produce too little. Why is Russian science unable to take full advantage of its resources?

Putin would never admit it, but China — the other great power in the East — helps to highlight where Russia is going wrong. China also has a state-dominated economy, yet one that manages to create favourable research incentives. China's state-funded science system has its own problems, but is increasingly based on merit and competition and attracts foreign talent. Lively academic exchange with the West adds constant stimulus. And oriented towards the global market, industrial research in China operates in accordance with global demands, quality standards and management practices.

Russia, where anti-Western sentiment prevails, follows a quite different path. Fixed-term academic employment of postdoctoral researchers, who produce the majority of research in most countries, including China, is virtually unknown in Russian universities and research institutes. Instead, most academic scientists enjoy permanent positions for decades and feel little pressure to perform. Only a small fraction of public research spending comes as grants allocated through competition, with the rest being simply handed out by officials. The Russian Academy of Sciences — the country's foremost basic-research organization — is struggling to get on its feet after years of unproductive wrangling over money, direction and leadership.

Russia also puts too much trust in top-down innovation by state-owned companies— in aerospace and energy, for example. But these have struggled to develop, let alone export, innovative goods and ideas.

Russia's international political isolation, inflicted by Putin's erratic course and exacerbated by nationalistic rhetoric, is another obstacle. A recent crackdown on 'undesired foreign agents', including science-funding charities, sends a hostile signal to the outside world. Cronyism and corruption start at the very top and undermine trust in research (and business) opportunities.

Putin clearly understands this. He has promised to increase science budgets further and to tackle funding bottlenecks that hurt competitive science. And on the face of it, a new national science strategy he launched in 2016 looked positive.

Under that plan, government funding was supposed to focus on a set of societally pressing topics — including energy research, health, digitalization, and security — which many other industrialized countries have also prioritized. Underperforming institutes run by the Russian Academy of Sciences would be restructured, or closed, and funding decisions spread over more shoulders to eliminate wheeling and dealing. None of this has happened yet.

"The country must remove notorious bureaucratic hurdles to doing science."

Russia must wise up. If it's serious about science, then the steps are simple. Most urgently, the scattering of scarce resources indiscriminately among many large research organizations must stop. Grant money should be targeted towards the best projects and research groups. That's a goal that requires transparency, fair competition and international expertise to review the research — all eminently possible. A competitive programme to encourage young researchers to run independent groups for up to five years was launched last year by the Russian Science Foundation, a government-run grant-giving agency, and is a first step.

The country must go further, and remove notorious bureaucratic hurdles to doing science, including obstructive customs rules and import restrictions on research equipment.

A stronger Russia relies on a strong research base. Russian scientists — and the watching world — are tired of empty words. Putin defines himself as a man of action. Let's see some. ■

Making plans

They sound dull, but data-management plans are essential, and funders must explain why.

Data are the alpha and omega of scientific and social research. A versatile good, they exist both as raw material for producing knowledge and, when processed and interpreted with an expert eye, the end product of the exercise.

So it might sound like a truism that researchers should conscientiously handle, preserve and — where appropriate — share the data they generate and use. The problem is that this can be hard to do.

As science produces day by day a huge volume of data, it's a growing challenge to manage and store this information. To encourage this, many funders now ask applicants to submit a concise data-management plan with their grant proposals: effectively, a to-do list that details how an they plan to collect, clean, store and share the products of their research.

Such plans are important, and are something that *Nature* supports (we discuss them in detail in a Careers article on page 403). But to accelerate acceptance of what some might deem just another administrative burden, science funders and research institutions must work to streamline the process and to explain the need and benefits.

First, rigorously collected, well-preserved data sets — including meaningful descriptors or metadata — will help the data owners to reach solid, meaningful results. Second, they will help future investigators to make sense of and reuse data, thereby enhancing utility and reproducibility. Preserving comprehensive data, ideally for many years, also reduces the risk of duplicating science done by others.

Still, there is no single recipe for proper data management. The task varies according to the field of science, project size and the specific types of data in question. That makes cross-disciplinary common standards unlikely, so research agencies need to engage with different scientific communities to create formats that best serve specific disciplines. To avoid a hotchpotch of standards, formats and data protocols — undesirable in our increasingly global scientific enterprise — research agencies in all parts of the world must engage.

An initiative for voluntary international alignment of research data-management policies, launched in January by Science Europe and the Netherlands Organisation for Scientific Research, is an important step in that direction. And existing data stewardship in particle physics and genomics shows that internationally aligned data governance not only is perfectly doable, but also has a positive impact on collaborative research. NASA pioneered this approach, setting up a centre in the 1980s to specifically curate the data from the Infrared Astronomical Satellite.

The message must now be passed on to scientists who work in fields less familiar with big data. Many of these, at all career stages, are worryingly unprepared. A survey of European researchers last year revealed that many have never been asked to provide a data-management plan, and that most are unaware of policies and guidelines already in place to help them. Only one-quarter of respondents to the survey, carried out by the European Commission and the European Council of Doctoral Candidates and Junior Researchers, had actually written a data-management plan, with another quarter saying they didn't even know what such a plan might be. There is nothing to suggest Europe is unusual in this.

Funders and universities, then, must ensure that the rationale of data management, and the basic skills of exercising it properly, become part of postgraduate education everywhere. Training and support must go further and be offered at every career level.

The laudable move towards open science — under which data are shared — makes the need for good data management more pressing than ever: there's no point in sharing data if they aren't clean and annotated enough to be reused. If you haven't got a plan for your data, you need one now. ■