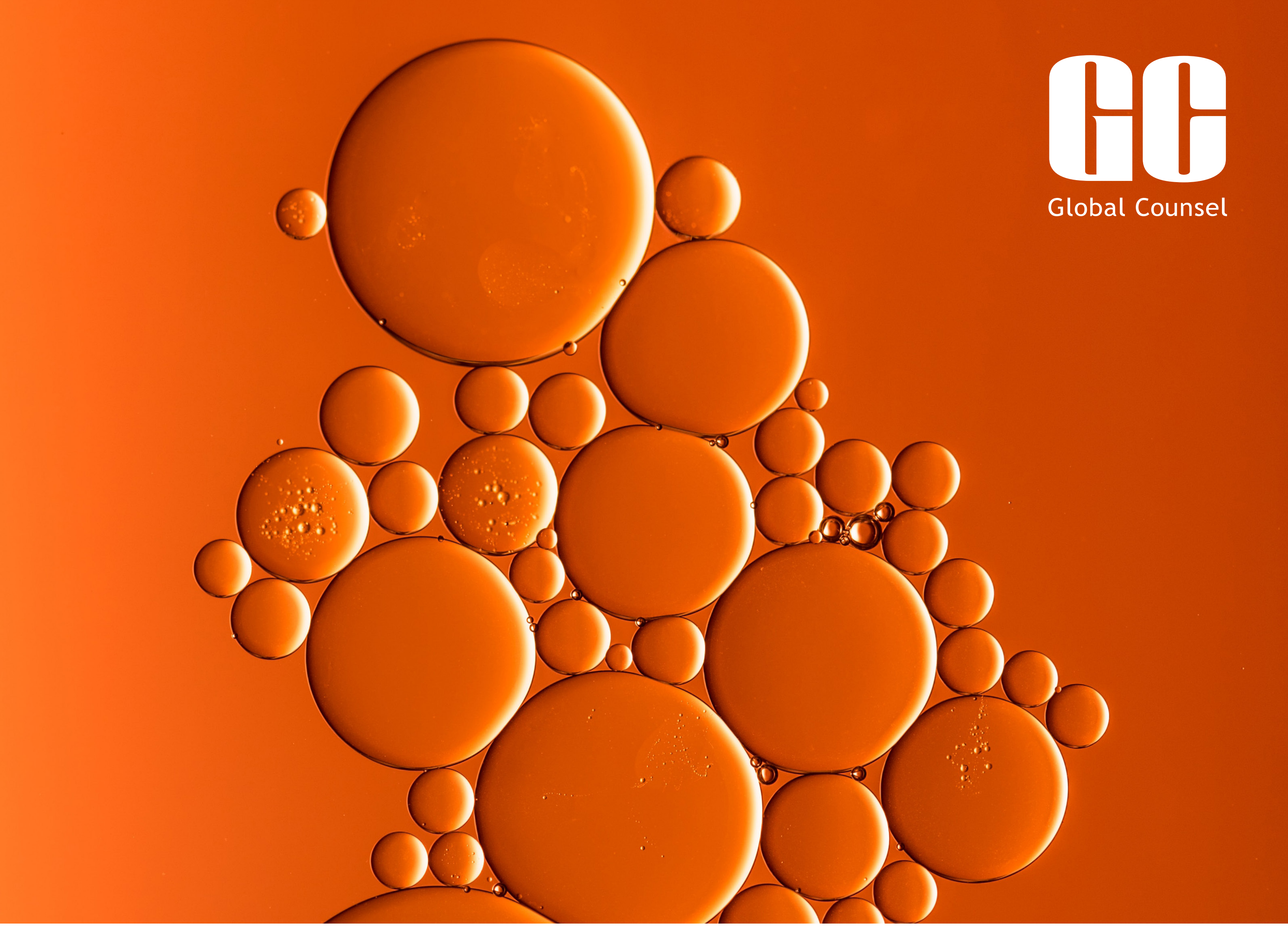

Global Counsel

The future of the physician: practice and policy

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The changing nature of clinical technology

The history of modern clinical intervention has been the history of the augmentation of human observation and instinct with technology. The stethoscope – the emblem of the modern doctor – started life in 1816 as a rudimentary way of making observations about the state of a patient's internal organs, reducing reliance on a patient's own self-description of their symptoms. The stethoscope allowed a much more nuanced investigation. It was the first tool used widely to diagnose illness and lead to the widespread approach of physical examination as the key to diagnosis.

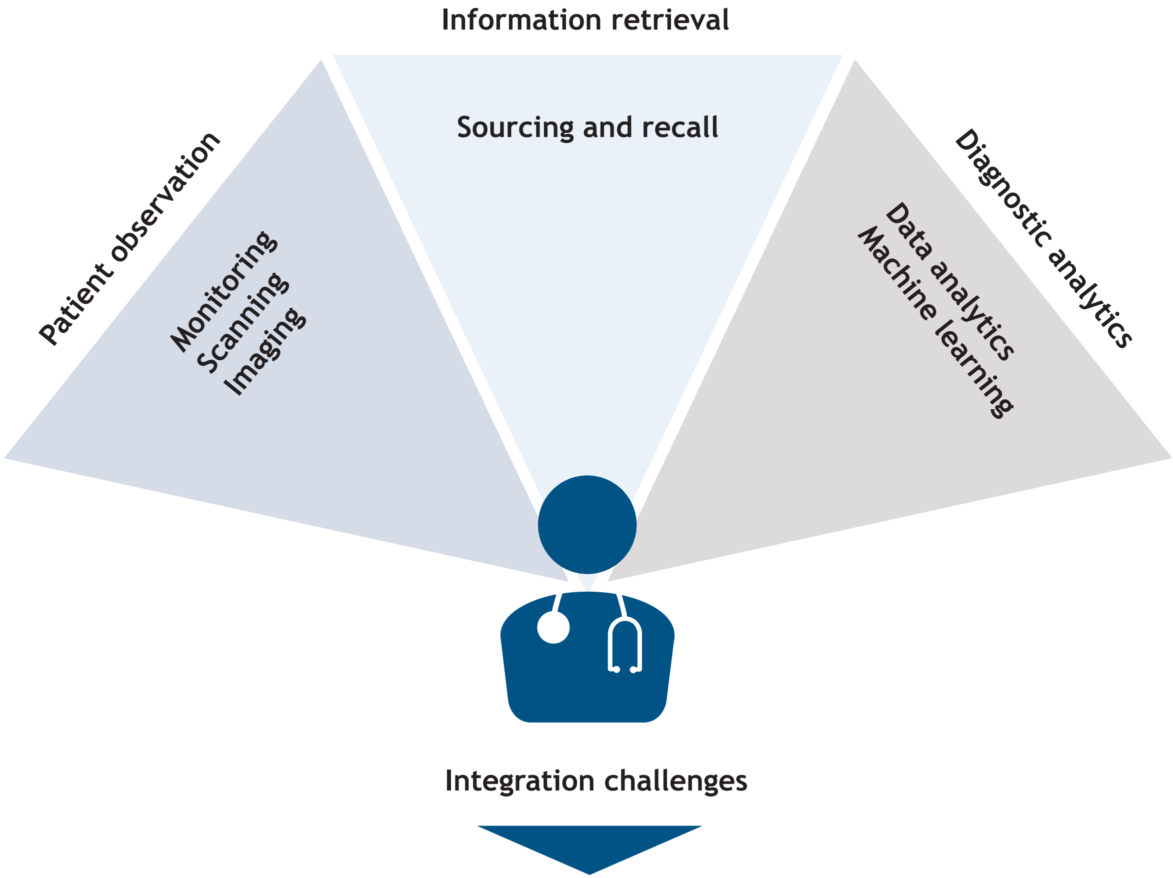
From this humble start, diagnostic technology has since transformed clinical practice. Its impact can be categorised in a number of broad ways:

- **Observation**. From the stethoscope and blood pressure monitors onwards, there has been an obvious value in technologies that augment the clinician's ability to observe, monitor and record a patient's status or symptoms. MRI scanners have transformed the way we monitor brain functionality and interventional radiology has transformed the way we observe and then treat the human body in minimally-invasive ways. Progress is developing rapidly, allowing both new observations and making existing ones faster and easier. For example, ElectronRX uses a smartphone to measure blood pressure, pulse, heart rate variability and vascular elasticity by imaging a fingertip. This allows for simple personal health monitoring and makes it easier for clinicians to collect time series data on a patient.

- **Information retrieval**. Clinicians have historically been required to learn and memorise huge volumes of information to underpin and enable both diagnostics and prescription. This can range from fundamental anatomy and biochemistry to detailed drug interactions, to interpret a wide range of data from advanced diagnostic tools. One consequence of this has been very significant sub-specialisation, in part to manage the sheer scale of effective and rapid information recall. Reducing the memory load on physicians potentially enables a wider scope of clinical activity for any individual clinician, and boosts clinician confidence.

- **Diagnostic analytics**. Like most data, clinical data routinely requires analytical processing to produce actionable insight. This can range from simple time series observations to hugely sophisticated analysis of genetic material or internal imaging. Karyotyping and cytogenetics have been almost completely replaced by the easy availability of DNA sequencing data. The advent of improved computational tools can potentially provide pre-digested information more rapidly, as well as presenting appropriate decision supporting tools, so that the demand on physicians' own analytical capabilities can be reduced significantly.

The augmented clinician



Protocol change

Clinical operating protocols are often designed to be second nature for practitioners and change means new learning.

Technology trust

Machine intermediation requires trust and high confidence in technology. This requires simple interfaces and consistent reliability.

Alert fatigue

Technologies should not overwhelm a clinician with information or seek to direct a clinician in areas where they have a high level of confidence in their own judgement.

AI in clinical practice

Diagnosis

- Increased speed of diagnosis
- Increased accuracy of diagnosis

Reporting

- Information more readily available
- Tools for underpinning clinical judgement
- Clinician focuses on judgement and explanation

Treatment

- Proactive and personalised treatment

Shaping the workforce

Quality

- Training challenges: new skills in managing and interpreting machine learning tools
- Rapid rising skills demand over supply risks poor patient outcomes

Quantity

- Jobs displaced by automation in some areas and potentially created in others
- Shift in balance in workforce between diagnosticians and others

The role of machine learning

AI and machine learning bring the promise of further step changes. The fundamental gains are in efficiency and cost-effectiveness. AI tools that can analyse medical data such as microscopic sections from biopsies can revolutionise the speed and accuracy of diagnosis. Advances in genomics and image analysis can drive greater understanding of how complex diseases develop, allowing for more proactive and personalised treatment. AI solutions can make reporting more efficient, thus freeing up time for NHS staff to spend on direct patient care.

DeepMind Health's OCT project with Moorfields Eye Hospital found that the new system could make the correct diagnostic decisions with 94% accuracy across 50 different eye conditions, with at least as good a performance as world-leading eye experts. Importantly, rather than simply producing a diagnosis (and estimated likelihood) it also provides a fully annotated visual analysis of the eye scan, saving many hours of a skilled expert's time and ensuring that decision review is easy. Approaches like this mean better diagnoses are possible and faster, and allow clinicians to focus on decision-making and explanation.

Surgery has historically developed at different timescales to other branches of medicine. While robot assisted surgery exists, it is much less widely used than was predicted. For example, minimal access surgery is not heavily used for abdominal procedures, despite the obvious benefits. Da Vinci is the market leader for robot surgeries, but the robots are ultimately expensive to operate and difficult to use, which has minimised their uptake at scale.

While the work of the physician in general has become very scientifically driven, surgery remains much more of a craft. Every patient is different, and surgery is done by individual doctors, who will have their own personal style. Where pharmaceuticals and medical devices can be measured and checked to be virtually the same, parameters such as the pressure used on a scalpel cannot even be measured at the moment, making it very hard to do detailed studies on what works with any statistical power or meaning.

There are ways, however, in which AI is making progress in the surgical world. CMR Surgical, for example, has a product know as the Versius System which is used for minimal access surgery. It is a small and mobile robotic system with a design that is suitable for an operating room environment. Its portability makes transporting it between surgical suites easy and, given its mobility, it is also cost effective. Its intention is to make work easier for surgeons and safer for their patients.

The changing clinical workforce

As roles continue to change, the perennial question therefore turns to wider aspects of the workforce – specifically the quality (who is needed) and the quantity (how many) variables of the clinical workforce. In some areas, there is a huge shortage of clinicians, resulting in treatment backlogs. An example of this is radiology, where the number of radiologists needed has simply not kept up with demand stemming from both volume and complexity of imaging. Increasing their efficiency by replacing lower-skilled aspects of the job would therefore be very welcome.

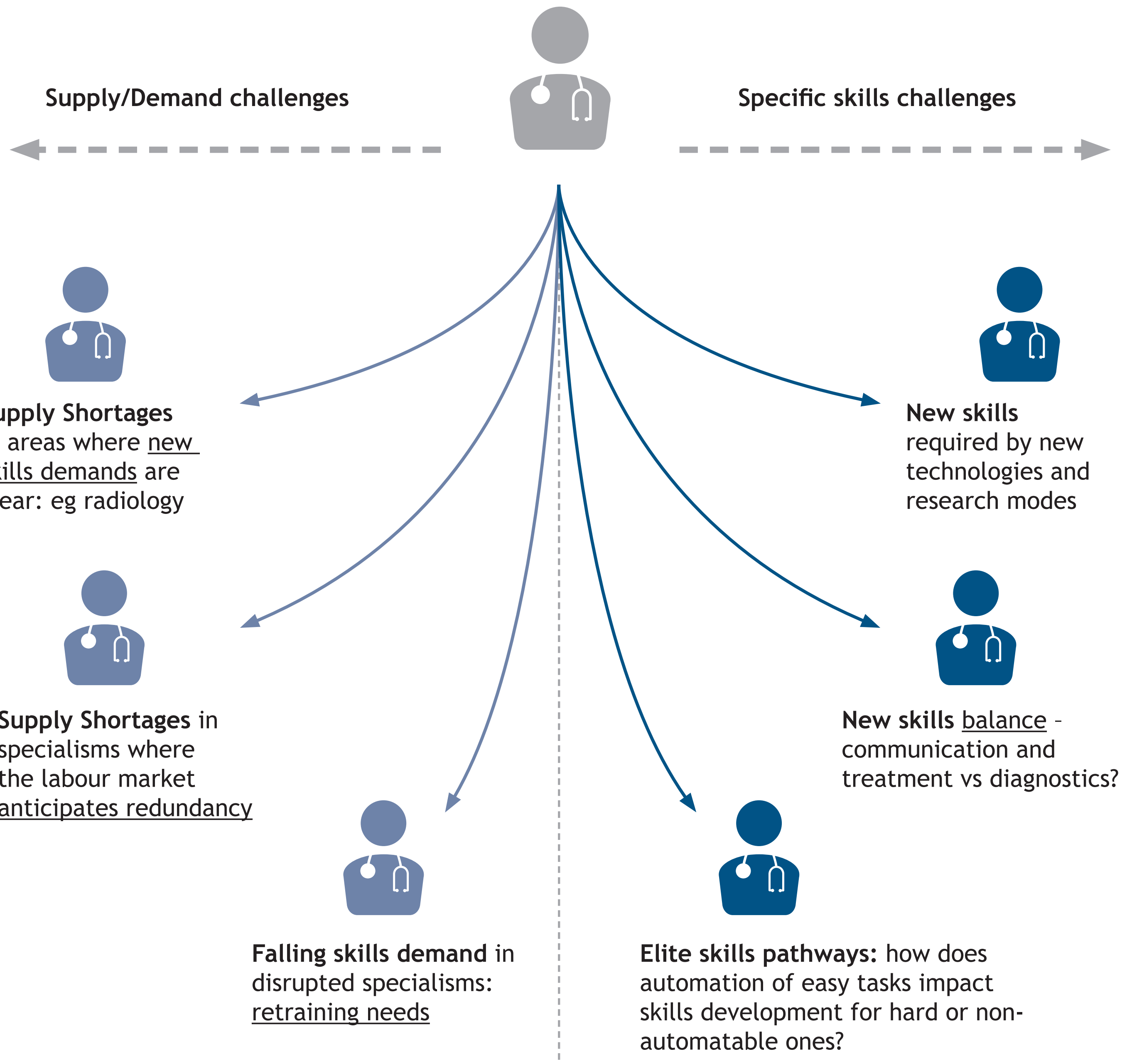
In other areas, a sudden loss of demand for people with key skills and experience will cause a lot of problems and replacement techniques may involve a very different skill set. With moderately rapid change, there is a risk of problems happening both before and after transition to a new technique. People are unlikely to want to train in subspecialties that are likely to be displaced – this may lead to serious shortages, especially at lower grades. On the other hand, after a full transition to newer technologies, there may be an excess of people whose hard-acquired skill sets may no longer be needed. These changes in skill sets and people required create a huge training challenge.

In the longer term, it seems likely that most physicians will be enhanced GPs, focusing on communicating information to patients, and with a particular focus on helping patients understand risk. Increasingly, they will be supplied with interpreted diagnostics results, processed remotely, and including patient-collected data. It is likely they will have a much stronger public health role, including a strong focus on health inequalities, and dealing with the holistic patient.

A few physicians will be diagnostic experts – many fewer than there are currently. They will supervise the output of largely automated diagnostic tools, dealing with the cases where the automatic analysis seems to be wrong, or the machine learning is not certain. Surgery will be increasingly more technical and measured, increasingly done with extensive robotic assistance and feedback.

If this is true, what is the training that will be needed for the doctor of the future? For most, it will require a greater focus on communication skills, especially around risk and public health messages, and more holistic interaction with the patient as a whole, rather than focusing on specific organ systems. Given that there is unlikely to be more overall time for training, this will necessitate a reduction in other aspects of training – perhaps biomedical knowledge.

New technologies; changing workforce challenges



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