

THE GLOBAL AI ISSUE

From miles to an inch

# AI IS CHANGING THE WORLD ONE STEP AT A TIME

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Tackle global chronic  
disease with AI

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The legal liability  
of AI

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The emergency physician  
who wears many hats

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Insights from renowned influencer  
of digital medicine, Eric J. Topol



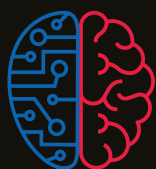
## THE DEEP DIVE

How AI is impacting  
Rwanda, India and UK

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**AI Med**  
CARDIOLOGY

# EXPERIENCE THE FUTURE OF CARDIOLOGY & CARDIAC SURGERY

**RITZ CARLTON**  
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The Sharon Disney Lund  
Medical Intelligence and  
Innovation Institute (MI3)

**17-18 JUNE 2019**

**Key topics**

Deep Learning and Cardiac Image Interpretation  
AI in Decision Support in Cardiology and Cardiac Surgery  
Precision Cardiovascular Medicine  
Big Data and Databases in Cardiology and Cardiac Surgery  
Wearable Technology and Embedded AI for Cardiac Care  
Robotics and Virtual Assistants  
Augmented/Virtual Reality in Cardiology and Cardiac Surgery  
Future of Heart Program Administration Using AI  
Medical Education and Training Using AI  
Blockchain and Cybersecurity in Heart Program

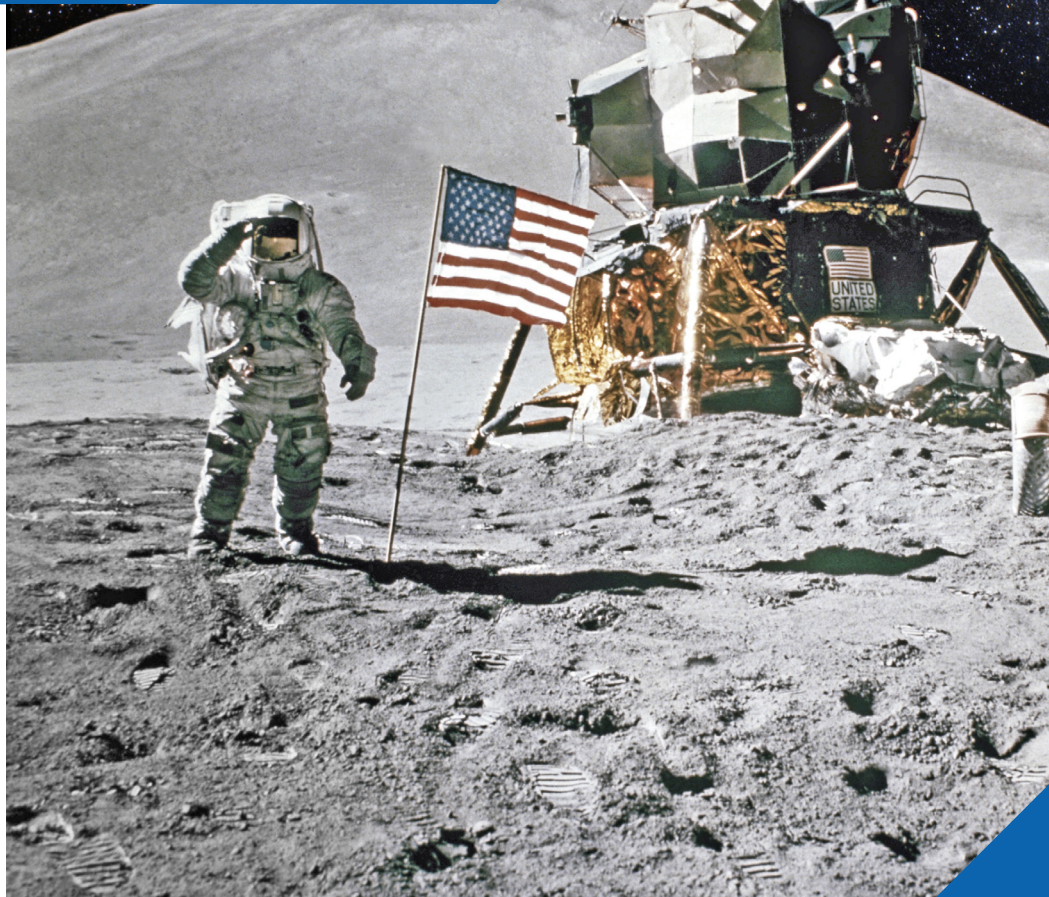


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## SYNERGY FOR MOONSHOTS

**A MESSAGE FROM AI MED CHAIR AND FOUNDER DR. ANTHONY CHANG**

“We set sail on this new sea because there is new knowledge to be gained, and new rights to be won, and they must be won and used for the progress of all people. Whether it will become a force for good or ill depends on man, and only if the United States occupies a position of pre-eminence can we help decide whether this new ocean will be a sea of peace or a new terrifying theater of war. We choose to go to the moon...

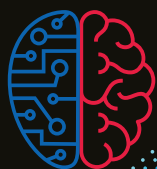
We choose to go to the moon in this decade and do the other things, not because they are easy, but because they are hard; because that goal will serve to organize and measure the best of our energies and skills, because that challenge is one that we are willing to accept, one we are unwilling to postpone.”

**JOHN F. KENNEDY, SEPTEMBER 12, 1962**

**T**hese words inspired a whole nation to eventually land a man on the moon as we reminisce during the semi-centennial of the lunar landing in 1969.

For me, this nostalgia resonated with the news that the American AI Initiative was finally declared as a gesture to join the Europeans and the Chinese in placing AI in the highest echelon of national priorities. ▶





**AI Med**  
RADIOLOGY

# EXPERIENCE THE FUTURE OF RADIOLOGY

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## 18-19 JUNE 2019

### Key topics

The need for unbiased Ground Truth Data.

Overhaul of IT infrastructure within the healthcare system at large.

Patient privacy/protection issues.

Develop comprehensive partnerships between clinicians with the vendor community to develop tools of clinical utility and usability.

How do we speed up research without putting scientific integrity at risk.  
Is there a hybrid model?



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#### TALK TO DR CHANG

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This issue of *AIMed Magazine* focuses on the global community of AI in medicine and healthcare. The AIMed team traveled to many cities and countries last year, and the universal theme that prevailed was: *empowering patients and enabling clinicians to use AI to be innovative and transformative*. From a plastic surgeon in Toronto who leveraged deep learning in medical images to improve her care of burn patients to the data scientist from Senegal who is working on reinforcement learning models in healthcare, these global AI in medicine citizens all inspired me and our team to continue our mission of creating an AI in medicine and healthcare ecosystem and community to affect transformative change.

This *esprit de corps* of the AI in medicine community reminds us how essential synergy and collaboration is in this domain. Synergy needs to be fostered in AI in medicine and healthcare at all levels. First and foremost, synergy needs to be between human and machine. There are numerous published manuscripts in which there are no clinicians amongst the authors as if data science in medicine can be an entirely isolated discipline and science. This hubris, albeit unintentional, is unacceptable. On the other hand, clinicians need to be much more knowledgeable and accommodating of this new AI paradigm in medicine. Second, synergy needs to be between human and human. The clinician and data scientist dyad needs to be engendered and much more effective in creating an important interface between data science and clinical medicine and healthcare. Third, synergy needs to be between machine and machine. The advent of internet of things is leading to the need for AI to be embedded in wearable technology. Thus, the future will be machine collaborating with machines to become internet of everything. In addition, deep learning algorithms will need to be in synergy with those principles of cognitive architecture to maximize the yield of AI in medicine and healthcare.

The quest to go to the moon had a sense of urgency and destiny, and we need to have the same for AI in medicine. Although it is unlikely AI in medicine will ever experience a cataclysmic event like the lunar landing, perhaps we are nearing this Sputnik moment in AI in medicine and healthcare. The television audience saw a very grainy black-and-white picture of this monumental moment in history. We should be seeing the amazing potential of data and AI like *Earthrise*, the photograph of our planet that the world saw on Christmas Eve in 1968. Perhaps this is symbolic: we have to travel out of our own domain to see the real beauty of what we have.



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# NOTE FROM THE EDITOR

## AI - Developing Speed in Developing Regions

Welcome to another edition of AIMed Magazine. The theme of this issue is Global AI and though its always easy to focus on Silicon Valley and China and make parallels between the two but we felt it would be more rewarding to illuminate areas like Africa and India, regions where there is a distinct paucity of healthcare professionals, resulting in an uneven skilled physician to patient ratio across many cities but more acutely challenging in rural and limited resource settings. Clearly there are many other challenges other than physician shortages across the developing world that hinder access to basic healthcare but AI, specifically expert systems, have the potential to alleviate the burden placed on healthcare systems and improve public health outcomes.

We will however need to consider the socio-political, epidemiological and ethical ramifications of how AI is implemented in developing countries, keeping front and centre issues around privacy, bias and informed consent. AI has the power to reduce health inequities rather than exacerbate them and i am confident that if we can approach these challenges holistically and pragmatically, AI will ultimately become a force for good.

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LEAD FEATURE

# TACKLING THE GLOBAL CHRONIC DISEASE BURDEN THROUGH **ARTIFICIAL INTELLIGENCE**





BY DR SANDEEP REDDY

The World Health Organisation estimates major chronic diseases account for almost 60 percent of mortality and 43 percent of the global burden of disease. In the US, half of the population has some form of chronic disease. However, responses to date to address these chronic diseases have been largely inadequate.

The main reasons for this include a non-evidenced based approach to managing the burden, incorrect beliefs about the cause and distribution of chronic diseases, system and financial constraints. Evidence suggests that when chronic disease patients receive effective treatments, self-management support, and regular follow-up better health outcomes ensue.

Given that the current and entrenched acute care-oriented health systems appear to be struggling to reorient towards preventative and primary care approaches; new and innovative models for chronic disease care are being welcomed by healthcare professionals. One such novel approach is the use of Artificial Intelligence (AI) in the treatment of chronic diseases. AI has been found to enable new evidence-based approaches to treat chronic diseases, reduce costs and enable better patient compliance with treatment. AI is increasingly being employed in medicine with promising results and its use in addressing chronic disease burden will similarly have a profound effect.

With the availability of health data from several sources including smartphones, wearable devices, electronic health records and other sources, there lies an opportunity to analyse this data to formulate appropriate and personalised treatment and disease management regimens. Previously, the lack of appropriate tools and infrastructure to undertake analysis has meant much of health data lay unused. With the advent of machine learning and associated computing infrastructure, there is an ability to harness and analyse patient data to deliver personalised healthcare. This opportunity matters as we observe ever-increasing avoidable hospitalisations and readmissions.

Use of machine learning can help in identifying at-risk patients and enable targeted intervention to prevent hospitalisations and readmissions. Not only can this approach improve patient outcomes, it can also save costs. The US Agency for Healthcare Research and Quality estimates over \$30 billion is spent on hospitalisations in the US, of which over 50% is due to chronic

diseases. By reducing hospitalisations through intensive treatment of identified patients in outpatient settings and preventing readmissions through early intervention and better care, billions of dollars can be saved.

Of all the chronic conditions, Diabetes and Cardiovascular Disease are the most costly and prevalent chronic conditions in the US, and stand amongst the top 10 costliest and prevalent chronic diseases in the world. The rest of this article will highlight how AI is assisting the treatment and management of these two conditions.

### DIABETES

Diabetes is a public health issue in the US affecting nearly 30 million people. Diabetes includes type 1, type II and gestational diabetes. For the purpose of this article, we will focus on type II, which is the most prevalent. Longstanding diabetes can lead to cardiovascular, nephropathic, neuropathic and other complications. These complications can drive up healthcare costs, both for patients and healthcare services. One of the main reasons for patients developing complications is because of poor treatment adherence. AI has been recognised to have a role in improving patient compliance with diabetic treatment and engagement with health providers. Although the main parameter of interest in managing diabetes is glucose, availability of additional information like nutrition and physical activity through wearable devices and other digital devices can help clinicians and health services track a patient's complications and compliance alongside their well-being. By integrating patient data derived from home settings like blood glucose

levels, nutrition, sleep and physical activity with electronic health record data, machine learning algorithms can predict the emergence of diabetic complications. By becoming aware of the possibility of complications, clinicians can intervene early to prevent complications.

Evidence indicates frequent communication between diabetic patient and physician, coupled with monitoring of patient-derived data limits the progression of the disease. Use of medical chatbots and telemedicine can assist elderly diabetic patients in medication adherence and scheduling follow-up visits to the doctor. Virtual health coaches can be used to advise patients about medication and nutrition-related information. In the context of chronic disease, prevention is better than cure when it comes to treatment. It is also known that preventing or delaying the emergence of diabetes type II can not only be beneficial for individuals, but also financially beneficial for health systems. The most efficient approach to realise these benefits is by using AI techniques, like machine learning, to modify risk behaviours and predict the development of chronic conditions. By adopting advanced computing techniques like machine learning coupled with behavioural modification, the AI applications present a promising option for health services to trial and adopt.

### CARDIOVASCULAR DISEASE

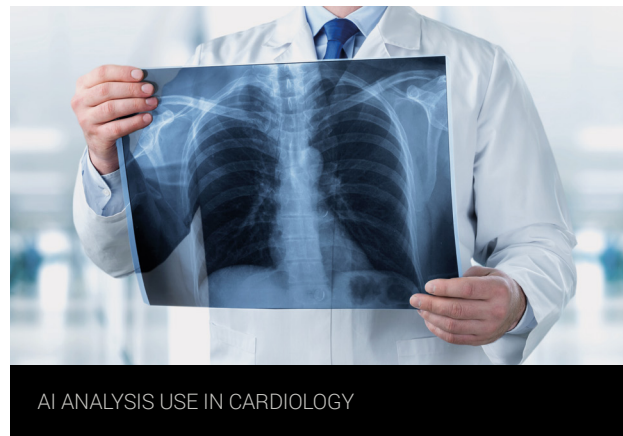
Cardiovascular Diseases involve the heart and blood vessels and include conditions such as coronary heart disease and heart failure. By far the leading cause of death across the world are cardiovascular diseases. Therefore, early prediction and diagnoses of heart conditions can prevent unnecessary deaths. In recent years, machine learning algorithms have shown great promise in predicting the risk of heart attacks and strokes. Currently, primary care clinicians use risk calculators to assess patient risk of developing heart diseases. However, these tools rely on data captured at that moment and do not assess longitudinal data. However, machine learning algorithms, through a combination of data mining and analysing electronic health records, can automatically predict the risk of heart diseases. In fact, a study from the Francis Crick Institute demonstrated an AI model that could beat doctors in predicting heart disease deaths. The model trained on electronic health data of over 80,000 patients in the UK searches for patterns by picking the most relevant variables to predict the risk of heart diseases.



Machine learning algorithms can also be used to analyse electrocardiograms (ECGs) and echocardiograms in detecting heart diseases, such as ventricular dysfunction, in its early stages. Early detection can help with better management of the condition. Here the model, similar to the heart disease predictor model, is trained on a large database of ECG and echocardiogram data to recognise a specific type of heart diseases. Then, it is tested on an independent set of patient data to assess accuracy, sensitivity and specificity. Machine learning algorithms such as convolutional neural networks can be used to analyse echocardiography and MRI cardiac images to recognise abnormalities; thus improving clinical work flow and enabling cost savings. Finally, with the aid of wearable devices and smart watches, AI tools can help in

identifying early warning signs of heart attacks. Devices that use ECG sensors can detect abnormal heart rate and rhythms and, in conjunction, machine learning algorithms can monitor the heart rate and rhythm to track efficacy of cardiac interventions and lifestyle changes.

The above were only two chronic conditions where AI has shown usefulness, AI has also shown efficacy in detecting cancer conditions, helping with treatment of chronic respiratory conditions and improving mental well being of mental health patients. Thus, AI as a technology has promising application in the area of chronic disease treatment and management. Collaboration between academic centres, AI vendors and health services will be required to progress the use of AI to address the chronic disease burden. ■



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### HONG KONG

**HONG KONG ENJOYS A LONGSTANDING AND WELL EARNED REPUTATION AS A GLOBAL FINANCIAL CAPITAL. BUILDING ON THIS REPUTATION, HONG KONG SAR IS EMERGING AS A VIBRANT 21ST CENTURY TECHNOLOGY HUB AS WELL.**

**A**lready home to more than 2,600 startups, Hong Kong boasts strong government support for innovation, including a light-touch approach to immigration, business-friendly R&D tax credits and the Greater Bay Area initiative which promises greater connectivity between Hong Kong and the manufacturing and innovation powerhouses of Shenzhen and Guanzhou.

In fact, this rapidly growing ecosystem was ranked #1 for ease of starting a new business by Savill's in its annual ranking of technology cities ([www.savills.co.uk/tech-cities/index.html#hong-kong](http://www.savills.co.uk/tech-cities/index.html#hong-kong)). And while attention is more frequently given to Hong Kong's fintech and e-commerce sectors, there's plenty for healthcare entrepreneurs to get excited about.

Public institutions like ASTRI collaborate with local and global companies to accelerate research in key areas such as healthcare, and operate under a mandate to deliver beneficial new technologies to the people of Hong Kong.

The Healthcare Devices Innovation Hub, housed in the expansive Hong Kong Science and Technology Park, take startups to the next level whether regionally or internationally. Through leading incubation and acceleration programs, it's shared facilities provide guidance, mentorship and required technology – such as 3D drawing and simulation software or 3D printers and testing facilities – to help facilitate the entire R&D process from prototype testing to clinical evaluation.

The Hong Kong Hospital Authority recently launched a new data lab, anonymizing a large repository of healthcare data and enabling academics and entrepreneurs to collaborate in training new machine learning algorithms.

In an upcoming issue, we will explore these further and meet the innovators behind Hong Kong's transformation from a financial center into a technology capital.







BY: JOANNA ASHBY

### DIGITAL HEALTH AND AI IN RWANDA

**KIGALI SURGERY INNOVATION HACKATHON 2018: LEVERAGING DIGITAL HEALTH AND ARTIFICIAL INTELLIGENCE FOR STUDENT INNOVATION AND LEADERSHIP AT RWANDA'S FIRST SURGERY-THEMED HACKATHON.**

**R**wanda is fast becoming a leading tech hub on the African continent and pioneer in digital health in Africa, emerging as a key tech and investment zone. The recently launched Co-Creation Hub, or CcHUB, is a design lab based in Kigali, and has branched from Nigeria where the goal is to bridge the gap between government and citizens to improve technology delivery for public services. Their investment of \$11 million (Rwf 10 billion) is set to put Rwanda on the digital map. But already, Rwandans in remote villages are using artificial intelligence, telemedicine, medical drones, health apps, and mobile solutions. By using artificial intelligence-based algorithms on their mobile phones, Rwandans are able to get a diagnosis for their health problems and doctors in Kigali are able to consult their colleagues in the Western Province about radiology cases through telemedicine. Blood is delivered by Zipline's medical drones – critical to national health and surgical systems - and a central electronic health records system ensures data is collected about health activities.







## THE DIGITAL LANDSCAPE IN RWANDA

But how is this all possible? It started with cables and broadband. 90% of the country is covered by 4G, some are even using 5G, and fiber optic cables are covering the majority of the country. In addition to this, mobile phone penetration is 75% and recently smartphone penetration has skyrocketed as well. With all this opportunity, medical students got to work to integrate and inspire their classmates to join the digital health revolution happening around them.

in Boston, USA, was coordinated by Joanna Ashby, Paul Farmer Research Associate on the program and medical student at University of Glasgow in the United Kingdom. The organizing committee included Arsen Muhumuza, Patrick Ischimwe, Anne Ndindwanimana, James Harelimana, Dominique Vervoort, Adelina Mazhiqi, Leni Gruendl, and Nabeel Ashraf.

Hackathons and focused on a central challenge that a group of students work on to develop an innovation solution to in a limited space of time. Global

Rwanda so students wanted to highlight the critical role that technology will play in realizing this national goal.

For this hackathon, we saw the integration of ideas from across the surgical system as well as the collaboration of students from a variety of technical backgrounds and areas of expertise. But what was at the core problem?

## GLOBAL SURGERY

Five billion people worldwide lack access to safe surgical care when needed, resulting in over 17 million preventable deaths each year and further, are responsible for one-third of the global burden of disease. To scale up access to safe surgical, anesthesia, and obstetric care for all, inclusion of future generations of health professionals, public health specialists, and policymakers from the start of global surgery discussions and interventions is essential.

To address this global crisis, students around the world came together and formed InciSion – the international student-led network for global surgery equity in 2014. Today, InciSion represents over 5,000 members in over 75 countries and fully established 35 National Working Groups across all world regions.

## KIGALI SURGERY INNOVATION HACKATHON 2018

Last December, the Rwanda branch of the student-led international network for surgery – InciSion – were at the helm of the organizing committee for the country's first surgery-themed innovation workshop. The Kigali Surgery Innovation Hackathon 2018 attracted over 100 delegates and 12 speakers that were both local and international.

The 2018 committee was led locally by Isaac Ndayishimiye, final year medical student at University of Rwanda and national lead for the Rwanda branch of InciSion. International partnership with the Harvard Program in Global Surgery and Social Change based

surgery innovation hackathons can be transformational in generating powerful discussions, facilitating knowledge exchange, and nurturing multi-disciplinary partnerships, as well as connecting students, trainees, and faculty many disciplines to join forces to tackle local and important surgical challenges.

The theme was 'Surgery Innovation' within the framework of the National Surgical, Obstetric and Anesthesia Plan (NSOAP) in order to emphasize sustainability. It was also selected as the week of the hackathon coincided with the historic inaugural opening ceremony of the Ministry of Health-led Rwandan NSOAP launch. This event celebrated the launch of the long-term vision for strengthening the surgical system in



“Five billion people worldwide lack access to safe surgical care when needed, resulting in over 17 million preventable deaths each year





## RWANDA IN CONTEXT

Once having the lowest life expectancy in the world subject to the 1994 genocide, Rwanda has turned around to become one of the most thriving African countries. Today, Rwanda faces the challenge of sustaining gains while tackling a mounting burden of non-communicable diseases including cardiovascular disease, cancer, diabetes, and others, a large part of which requires surgical care to manage. In December 2018, Kigali's University of Global Health Equity (UGHE) opened its medical school in early 2019 where Professor Abebe Bekele, thoracic surgeon from Ethiopia, became Dean and introduced plans to centralize surgical care within the new UGHE medical school's curriculum early on in the studies.

## WORKFORCE AND THE POTENTIAL FOR HEALTHCARE AI

Globally, there is a shortage of 4.3 million health professionals, and Sub-Saharan Africa alone bears 24% of the global burden of disease but is served by only 4% of the global health workforce. Health graduate schools face overwhelming financial, infrastructural, and personnel constraints in addressing this workforce shortage. What does Rwanda's surgical workforce look like today?

The surgical workforce in Rwanda comprises 53 surgeons, 18 anesthesiologists, 263 nurse anesthetists, and 70 obstetricians, according to a baseline assessment in 2017. This is in addition to 150 GPs. The specialist surgeons include 15 ear nose and throat surgeons, seven orthopedists, five urologists, five neurosurgeons, two oral maxillofacial surgeons, one cardiothoracic surgeon and one plastic surgeon. Most specialist surgeons work in referral hospitals but some also work in the provincial hospitals. This shortage is the ideal climate that is perfect for disruption, where image-based AI can improve access, affordability and equitable healthcare delivery.

## LEVERAGING DIGITAL AND AI-BASED PLATFORMS

Digital and AI-based technologies could also be woven into the existing student frameworks and initiatives and are organized today across the country. For example in October 2018, medical students organized a week long campaign in the Kirehe district, Eastern province of Rwanda, involving a one week screening campaign called 'Community Health Camp' covering six sectors of the district. A total of 4,326 people were screened for NCDs, for eye diseases alongside the provision of primary eye care services, blood pressure measurement, blood glucose, BMI, and patient education and counselling for NCDs.

Medical students are also involved in the delivery of short-term surgical solutions through partnerships with mission organizations, such as Operation Smile. These missions help underprivileged populations living in rural settings to access timely, affordable surgical care. These initiatives could be streamlined through the integration of digital health platforms, designed and developed by the people who understand the problems best.

Additionally, the Rwandan Ministry of Health is integrating novel and essential Minimally-Invasive Surgery (MIS) educational schemes into surgical training. Minimally-Invasive Surgery (MIS), ►

or “keyhole” surgery, is performed by making a small hole of 0.5-1.5 cm to access internal organs during an operation, thereby reducing the overall incision size, reducing the risk of associated complications. In partnership with the Rwandan and Belgian governments, Rwanda is implementing a five-year minimally invasive surgery project which trains surgeons in the country to be able to perform these procedures.

The combination of skilled medical professionals and improved access to hi-tech hospital equipment will improve patient outcomes, as well the reduce in the duration of hospital stays for

patients from days to hours, and risk of infection and surgical complications.

### CALL TO ACTION

The actions led by these values have the potential to accelerate a future where healthcare professionals work in close partnership with other key stakeholders from other fields of work, such as software engineers, business consultants, and product designers. The continuation of these initiatives will have an enormously positive impact on local health, global health, and global surgery – especially for patients who lack

access to safe, affordable surgical care close to home. “Thank you for this opportunity. I wish it took place every year.” said one attendee after the Kigali Surgery Innovation Hackathon 2018. “Great speakers, interactive, engaging. The next hackathon should be in Ethiopia” said another. What is next in store for the digital health leadership amongst this team of Kigali medical students?

### PLANS FOR DIGITAL HEALTH TRANSFORMATION IN 2019

Isaac Ndayishimiye recognized the student enthusiasm after the





“The opportunities for surgical innovation are huge in a world where digital tools are giving rise to new health platforms that are increasingly useful to surgeons, community healthcare workers, and patients alike



hackathon and ensured the sustainability of the initiative by rallying medical students from across the country to band together for Rwanda's digital future. Within a month he had coordinated the formation of three new student initiatives: the Rwanda Digital Health Initiative – a national task force to advance technology in health and surgery, the Digital Surgery Camp – a one week innovation fellowship organized in the format of an intensive accelerator, and the committee for next year's hackathon, to be held in June 2019.

“The opportunities for surgical innovation are huge in a world where digital tools are giving rise to new health platforms that are increasingly useful to surgeons, community healthcare workers, and patients alike” said Ndayishimiye in the event report for the Kigali Surgery Innovation Hackathon 2018. “Rwanda is on its way to a future of surgical care that is more predictive, preventative, and personalized, driven by innovations in digital health and AI.”

#### ACKNOWLEDGEMENTS

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BY: MAYUR SAXENA, JOANNA ASHBY

### AI: THE HOPE FOR INDIAN HEALTHCARE SECTOR?

**INDIA IS ONE OF THE LARGEST COUNTRIES IN THE WORLD AND HAS THE MOST ROOM FOR INNOVATIVE, SUSTAINABLE, AND SCALABLE HEALTHCARE TECHNOLOGIES TO IMPROVE LIVES. WHY?**

**T**hroughout India, there are vast inequalities in healthcare distribution, a lack of trained healthcare clinicians, limited infrastructure, and low government spending on healthcare. Yet, in a country with 1.4 billion people, many are connected to the internet and have smartphones. This offers a unique opportunity and has led to some of the success stories that are covered in this review of AI in India throughout the Indian healthcare system.

There is a disproportionately low number of skilled doctors in India. According to the Indian Journal of Public Health (Potnuru, 2017), India had 4.8 practicing doctors per 10,000 population. It is expected to grow to 6.9 per 10,000 people by the year 2030, but the minimum doctor to patient ratio recommended by the World Health Organisation (WHO) is 10:10,000. AI is an effective measure to increase efficiencies and tackle this uneven ratio, by making doctors more skilled at their jobs, catering to rural areas for a high-quality healthcare, and training future doctors and nurses.







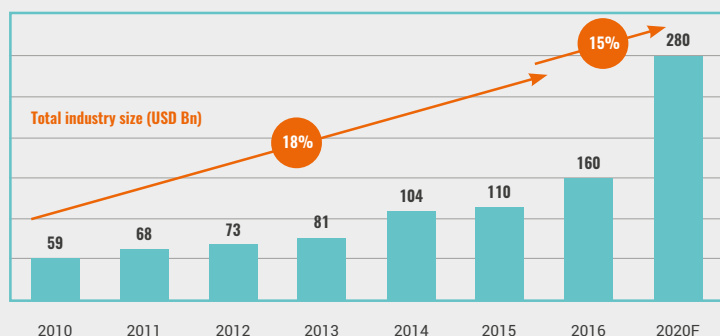
## HOW DOES AI IN HEALTHCARE FUNCTION?

According to OECD (Organisation for Economic Co-operation and Development) estimates, 20% of healthcare expenditures are wasted globally. The United States Institute of Medicine believes the figure is more like 30%. Using both estimates, when ranked by healthcare expenditure, the top 15 countries waste on average between \$1,100 and \$1,700 per person annually. Even more concerning is the fact that the underlying reasons

world. Machine learning can be used to merge an individual's omic (genomic, proteomic, metabolic) data with other data sources to predict the probability of developing a disease, which can then be addressed through timely intercessions such as preventative therapy.

## AI IN THE HEALTHCARE SECTOR IN INDIA

According to a study in 2016, the Indian healthcare market, which is worth \$100 billion, is likely to grow at 23%



for this waste include preventable and rectifiable system inefficiencies such as care delivery failures, over-treatment, and improper care delivery.

This is why the advances in artificial intelligence (AI) and machine learning are exciting from a healthcare perspective. AI can scan thousands of images and identify patterns in a fraction of time that it would take a human to perform the same task. Add machine learning to this, and we are looking at technology that can dramatically improve sensitivity and accuracy over time. Leveraging the cloud, these technologies would be capable of comparing every scanned image against the millions of data points gathered from hospitals across the

CAGR to reach \$280 billion by 2020. This growth, however, will be largely in the private sector. The reason is that the government policy in India forces the majority of its population of 1.4 billion to rely on private healthcare. The cost of services in the private sector is roughly four times to that in the public sector. Additionally, according to a United Nations Population Fund report, the number of people aged 60+ in India will increase from 100 million in 2011 to 300 million by 2050. Of these, 300, 200 million will suffer from chronic ailments such as cardiovascular diseases, diabetes, chronic kidney disease, and more. All these patients are going to strain an already understaffed healthcare system, creating a massive supply-demand gap.

This wide gap creates ample opportunity for a technology-enabled healthcare service model to cater to a rising middle and lower class in India as these solutions will bring down the overall cost of healthcare services. Furthermore, recently the public sector funded health insurance has been a national health priority. This will open opportunities for AI-based companies that can gather relevant pieces of data from across the country to create efficiencies in the much-needed health insurance sector. The technological innovation is proving to be beneficial in diagnostics, remote monitoring of chronic conditions, assisting in robotic surgery, and drug discovery. Microsoft is among several companies that are exploring various uses of AI in the healthcare space. They are taking a major initiative alongside major hospitals like Apollo to expand utilization of AI technologies in several focuses, including cardiology, ophthalmology, and infectious diseases like tuberculosis and HIV.

AI, however, is not limited to major technology groups like Microsoft, IBM, or Google. According to a report by CIS India (Centre for Internet and Society) published earlier this year, AI could help add \$957 billion (or 15% of current gross value added) to the Indian economy by 2035. This value will be captured by a number of AI startups that are incubated in the last few years.

The center and state governments are also providing support to AI start-ups by programs like Startup India & Startup Yatra. Thus, through creating opportunities for health-tech startups, such initiatives enable







companies to explore untapped niche sectors. In 2017, a report published by Inc42 DataLabs found that Indian healthtech startups alone raised \$346 million across 111 deals. Finally, the other startups at the leading edge of the Indian healthtech ecosystem include 1mg, Medfinder, Curefit, Practo, Curofy, Portea Medical, Medgenome, among others.

To focus in on a few examples, there are a variety of Indian Healthcare startups that are engaging in the use of Artificial Intelligence for either internal research or externally more directly with customers in mind. A few of these are now listed below:

1. Niramai, a Bengaluru-based start-up founded in the year 2016, that uses AI for pain-free breast cancer screening.
2. Sigtuple, a Bengaluru-based start-up that helps hospitals and healthcare centers to improve the speed and accuracy of blood reports.
3. Portea, a Bengaluru-based start-up that offers home visits from doctors, nurses, physiotherapists and technicians for patients. Patients who are unable to visit hospitals can receive assistance from doctors and medical professionals using remote

diagnostics, monitoring equipment, and point-of-care devices.

4. Tricog Health Services, a Bengaluru-based start-up that is set out to help doctors to make instant diagnoses of heart attacks and ensure treatment is not delayed.
5. AddressHealth, a Bengaluru-based start-up provides primary pediatric healthcare services to school children and screening for hearing, vision, dental health, and anthropometry.
6. Advancells, Noida, is a Noida-based start-up that focuses on therapeutic applications of Regenerative Medicine (stem cell therapy).
7. Artelus, is a Bengaluru-based startup that focuses on diabetic retinopathy. Their AI system captures the patient's retina image, analyses it and presents it as a report.
8. ChironX, Gurugram is an imaging AI expert that detects diseases from large populations of medical images.
9. LiveHealth, a Pune-based start-up works as a management information system (MIS) for healthcare providers. It collects samples, manages patient records, provides diagnoses and generates reports.
10. Qure.ai, is a Mumbai-based startup focuses on detection of abnormal chest X-rays and identification and localizes 15 common abnormalities. They also have a product that acts as diagnostic assistance in head CT scans.





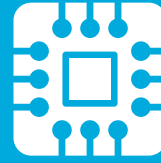
**“ Artificial Intelligence, the next-gen innovative technology, will act as an “invisible hand” in revolutionizing the healthcare sector and is expected to grow to \$372 billion in India by 2022. And there could not be a country more receptive to the benefits and transformations that artificial intelligence will bring.**

#### LOOKING TO THE FUTURE

Artificial Intelligence, the next-gen innovative technology, will act as an “invisible hand” in revolutionizing the healthcare sector and is expected to grow to \$372 billion in India by 2022. And there could not be a country more receptive to the benefits and transformations that artificial intelligence will bring. With every new advancement comes the realization of new challenges that must be faced, whether these relate to shortages in workforce delivery, geographical inequities, gaps in infrastructure, or urban-rural divides. The diversity and potential scale of the Indian healthcare system affords an opportunity and incentive like no other to pilot and operationalize such innovations. Each one of the systems that is failing for the Indian healthcare system today provides a unique opportunity for digital technology, and especially for AI.

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LIFETIME, A GERMAN-LED CONSORTIUM, WAS ONE OF  
THE SIX FINALISTS TO RECEIVE THE

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flagship science initiative from the European  
Commissions for its research on the use of AI and  
machine learning in personalized medicine.

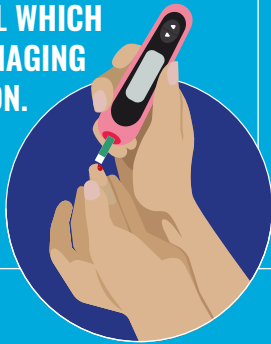
## 4-INCH

OF SPECIALIZED SILICON WAFER CAN BE MADE INTO  
A MILLION MICROSCOPIC ROBOTS IN A MATTER  
OF WEEKS USING THE LATEST NANOFABRICATION  
PROCESS DEVELOPED BY RESEARCHERS FROM  
UNIVERSITY OF PENNSYLVANIA. THESE CELL-SIZED  
ROBOTS CAN BE INJECTED INTO HUMAN VIA A  
SYRINGE AND AID IN BIOLOGICAL MISSIONS LIKE  
DRUG DELIVERY OR MAPPING THE BRAIN.

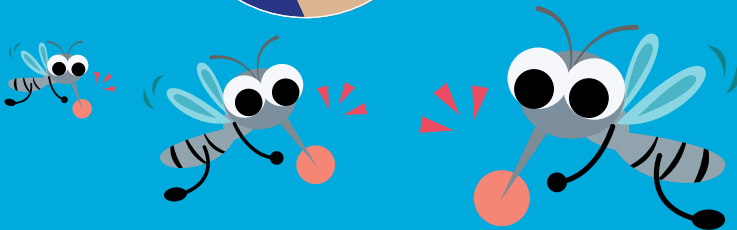


# 2000

SEVERE DIABETICS PATIENTS' DATA WILL BE COLLECTED BY THE JAPANESE GOVERNMENT TO ASSIST IN THE DEVELOPMENT OF AN AI TOOL WHICH HELPS IN MANAGING THE CONDITION.



The question of whether technology truly provides care is on the table again after a doctor announced to a 78-year-old that he has got days to live via a video link robot during a tele-visit.

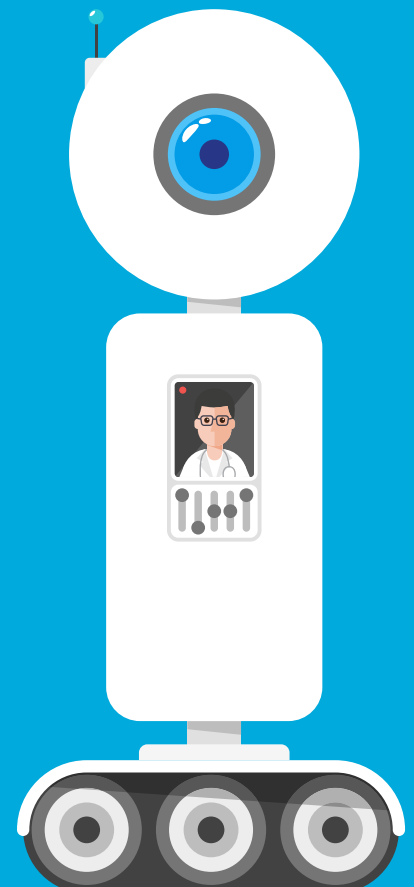


AN ALGORITHM DEVELOPED BY RAINIER MALLOL, A SCIENTIST FROM DOMINICAN REPUBLIC IS ABLE TO PREDICT THE ONSET OF A DENGUE FEVER OUTBREAK HAS A MATCH RATE OF

# 81%



NEW YORK COSMETIC BRAND IL MAKIAGE, GATHERED DATA FROM MORE THAN 700 SKIN TONES, TO DEVELOP AN AI ALGORITHM WHICH HELPS PEOPLE TO FIND THEIR PERFECT FOUNDATION SHADE.



BY: ELEONORA HARWICH, DIRECTOR OF RESEARCH, REFORM

### AI IN THE NHS

**MANY PLAYERS WANT TO BE A PART OF THE GLOBAL 'ARTIFICIAL INTELLIGENCE (AI) AND DATA RACE', WHETHER THEY ARE BIG TECH COMPANIES, INVESTORS POURING MONEY INTO START-UPS SIMPLY BECAUSE THEY MENTION THE MONEY-MAKING BUZZWORDS 'AI' OR 'BIG DATA' IN THEIR PITCH OR COUNTRIES DEVELOPING THEIR OWN STRATEGIES FOR HOW TO GROW THIS INDUSTRY. THE UK IS NO EXCEPTION TO THIS. THE GOVERNMENT CLEARLY HAS STATED THAT IT WANTS TO BE AT "THE FOREFRONT OF THE ARTIFICIAL INTELLIGENCE AND DATA REVOLUTION".**

**H**ealthcare is a field in which the applications of AI have caused great excitement. It is enabling the interpretation of mammograms 30 times faster than humans and with greater accuracy. Other areas of application get less publicised but could arguably be much more impactful (at least in the short-term), such as using AI to optimise back office functions (e.g. better scheduling, optimising the use of operating theatres or reducing dosage errors).

There is, however, a gap between the potential of AI in healthcare as portrayed in the media or the messaging of some of the companies developing this







technology, and the reality on the ground. Some products and services are being developed without a clear understanding of the issues faced by the workforce or patients. Private sector organisations can often fall into the trap of thinking about the tech first instead of trying to solve a problem that individuals face on the ground. This can have an impact on people's general uptake of the technology and their buy-in.

However, even when a service or a product is designed to solve a pressing issue faced by healthcare practitioners or patients, it might face other barriers which hamper its scaling. An intractable problem is that of the external validity of an algorithm – will a model trained on the data provided by hospital A based in the North of the country work for hospital B based in the South East? In addition, issues of data infrastructure and interoperability of IT systems can also hamper the scalability of a solution.

Aside from technical considerations, there have been some growing concerns about the nature of partnerships between NHS organisations and private sector companies to create data-driven innovations. As a response to these concerns, the Department of Health and Social Care (DHSC) released a non-mandatory Code of Conduct for Data-Driven Health and Care Technology in September 2018 which it updated last month.

It is extremely difficult to scope out the landscape of partnership agreements between NHS organisations and the private sector as there is no central repository of data access requests or data sharing agreements. This information is held at the organisation level (i.e. in the approximately 9,000 organisations working under the NHS banner) and not always made accessible online as revealed in a recent report published by Reform. The landscape is quite varied and ranges from simple data sharing agreements

with a cost recovery model (e.g. once a data access request is approved by NHS Digital the organisation accessing the data will have to pay a cost equivalent to the number of manhours needed to produce the data extract), licensing agreements (e.g. the Clinical Practice Research Datalink dataset operates on a tiered licensing model, which means that depending on who are you might pay a different price to access the data for specific purpose), to more elaborate commercial arrangements in which hospital trusts are offered equity shares.

Such types of commercial models are quite rare within the NHS as there is general a lack of clarity over what the value exchange is between NHS organisations, patients and industry when there is access to data to create a product or service. The private sector can be an important partner to the NHS in the development of healthcare technologies that use data collected by hospitals or GP practices. It provides the skills and know-how to develop data-driven tools which can be used to improve patient care. This exchange of value is not one-sided as the NHS makes the data available to build these tools and offers medical expertise to make sense of the data.

A further difficulty in understanding what a fair value exchange might be lies in the fact that healthcare data is an asset that no one knows how to adequately value. There are various factors affecting it and the definition of value might vary depending on a stakeholder's point of view.

It is crucial for DHSC to have a national strategy which ensures that organisations are not creating perverse incentives at a local level. ►

“ **Private sector organisations can often fall into the trap of thinking about the tech first instead of trying to solve a problem that individuals face on the ground. This can have an impact on people's general uptake of the technology and their buy-in.** ”





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**WHAT ARE THE CHALLENGES?**

**WHERE DO WE GO FROM HERE?**

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## THE DEEP DIVE

A hospital receiving a financial revenue from a partnership it has engaged in, increases the risk of some Trusts becoming much richer than others, which could potentially worsen healthcare inequalities. Another key component of a national strategy should be to keep society in the loop. In other words, patients should be able to participate in the conversation about what fair value exchange with the private sector might be.

In addition, reducing asymmetries of information between the private and public sector over what the value of an innovation might be would enable more informed conversations about a fair value exchange. Using privacy-preserving techniques like synthetic

data – a fake version of real data that is sufficiently different so that it preserves a person's anonymity, but sufficiently similar that it can be used for analysis – would help reduce these information asymmetries and enable better conversations about the appropriate type of commercial model that should be developed.

There are still many elements to consider and get right before the UK can truly achieve its goal of being at “the forefront of the artificial intelligence and data revolution” in healthcare. It is crucial that the Government does not miss this unique opportunity to harness the value of data driven technologies in a manner that is fair and beneficial to patients, the NHS and industry. ■







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## 01 ROBOTS ARE NOT STATISTICALLY INFERIOR TO HUMANS IN BREAST CANCER DETECTION

A recent study published in the Journal of the National Cancer Institute compares, at case level, the detection performance of a commercially available AI system and 101 radiologists. The study used a combination of cases collected from seven countries with digital mammography (DM) exams acquired by four different vendors, as its dataset.

A total of 2652 examinations (653 malignant) were made by 101 radiologists in 28,296 independent interpretations. The targeted AI system analyzed these DM exams with a level of malignant suspicion between 1 and 10. Statistical analyses showed that the AI system achieved comparable accuracy to an average radiologist in such retrospective setting.

## 02 FDA'S 'REQUEST TO CONNECT' PORTAL IS NOW LIVE

US Food and Drug Administration (FDA) launched an online portal on 8 March targeted at healthcare professionals, patients, caregivers, advocates and patient groups, providing a place to pose questions or request meetings concerning the topics of drug, device or medical products.

The portal was co-developed with FDA's patient affairs staff and medical product centers. It aims to encourage understanding and participation of how FDA regulation works as patient population become more informed in this complex digital age. This is part of the FDA's effort to hear more from patients and try to instill their perspectives into the agency's work and approval process.



## 03 EXPERTS FEAR THE NEW CODE OF CONDUCT FOR AI IS INADEQUATE

The UK government published a new set of rules recently to regulate and protect the use of patients' data in AI development. University College London's lecturer Melanie Smallman sees the move as a good start and its potential to become a global benchmark.

At the same time, Smallman, who researched on the relationship between science and society, also noted its inadequacy as the code lacks the sophistication to address inequality. Smallman fears future guidelines may only benefit those who have access to AI and those who have been accounted for in the algorithm. Others left behind may either have to pay more, travel further or in the worst case scenario, forego healthcare.

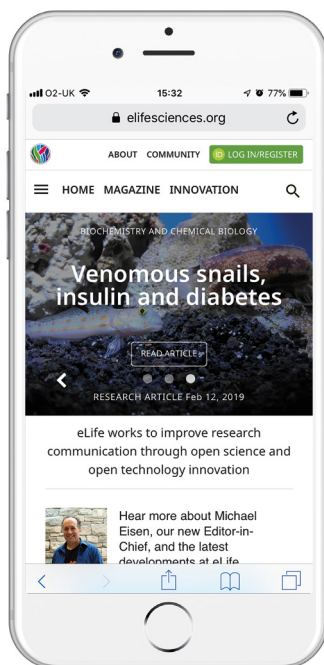




#### 04 TWO NEW AI-ASSISTED SECURITY TOOLS TO QUICKEN THREAT RESPONSE RATES

Azure Sentinel and Threat Experts are the two latest cloud-based security tools which use AI to ensure any potential cyber threats are quickly dealt with. Developed by Microsoft and released in March, both Azure Sentinel and Threat Experts have built-in machine learning algorithm trained using trillions of daily signals to eliminate noise from any risks.

Azure Sentinel can be integrated into existing tools, to connect and collect data from various servers and devices. While Threat Experts is a service resting within Windows Defender ATP for the benefit of any security operation centers. Microsoft believes the new tools promote a more proactive threat hunting.



#### 05 JOURNAL ALLOWS SHARING AND MINGLING OF PUBLISHED RESEARCH RESULTS

Online journal eLife, published its first ever "computationally reproducible" article recently. The data and figures in the article are not only made available for others to read, but the embedded R and Python codes permit them to validate or build on the existing work.

To do so, users can click on the blue arrow found around each of the figure, to reveal the underlining code block. Users can then manipulate the code to recreate the presented results or test the effects of removing outliers. eLife is believed to be the first to make code a native part of a research work and most scientists regard this as the journal of the future.

## 06 RESEARCHERS ARE USING AI TO MAKE BETTER FLU VACCINE

A Boston based startup, Berg is now working alongside with French pharmaceutical giant Sanofi to analyze data of patients who had received flu vaccine. With the use of AI and machine learning, they hope to better understand the biological processes that trigger immune response to flu and develop more effective and personalized flu vaccine.

By collecting flu samples from around the World to determine which strains to include in that year's shot. If successful, it is believed that the approach will radically change the way of present practice.





A man with dark, curly hair and a beard is smiling at the camera. He is wearing a blue denim button-down shirt. He is holding a large, rectangular, pink sign in front of his chest with both hands. The sign has the words "HUMAN" and "EMPOWERED" written on it in white, bold, sans-serif capital letters. The background consists of lush green foliage, possibly palm fronds, which are slightly out of focus.

**HUMAN  
EMPOWERED**



# IT'S ALL ABOUT THE GROUND TRUTH

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**THE ART AND SCIENCE OF DIAGNOSTICS IS PERHAPS THE MOST DIFFICULT CHALLENGE FOR AI AS EACH CLINICIAN'S DECISION IS OFTEN INFORMED BY A LIFETIME OF EXPERIENCE AND STUDY**

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**A**s the AI revolution continues to grow, companies increasingly recognize that the magic wand of automation needs the hand of human intelligence to wave it. In industry parlance, this human intelligence is conveyed to AI models in the form of what is termed “ground truth” training data. The algorithm learns iteratively by looking a large number of data points which have been annotated (key portions of the data segmented) and labeled (classified) with the desired answer. Over a period of time the algorithm becomes better at matching the answer and eventually can generalise its operation to previously unseen data. ▶

# “ A KPMG report released in 2018 showed that investment in AI for healthcare had reached almost \$1.3 billion across 107 deals in 2017.

In practical terms, an AI algorithm can only succeed if it has access to well structured training data which has been labeled at high accuracy by a human workforce. The old adage of “garbage in garbage out” applies even more in the world of machine learning. Herein lie both the challenges and opportunities of building large scale accurate datasets using human judgements and decisions. In the booming healthcare space, this problem is further intensified by the needs of deep domain expertise, regulatory barriers, and complexities surrounding data management.

A KPMG report released in 2018 showed that investment in AI for healthcare had reached almost \$1.3 billion across 107 deals in 2017. The report also noted that access to the right data at scale is a critical enabler of artificial intelligence in this space. While algorithms like TensorFlow and large scale computation resources like the cloud, have become widely accessible to big and small players, the data factor remains a crucial differentiator in the success of these investments. A year later, investment and interest in the medical AI space has grown even further as AI-powered technology begins to emerge in the marketplace to tackle everything from patient care to back-end operations.

The art and science of diagnostics is perhaps the most difficult challenge for AI as each clinician's decision is often informed by a lifetime of experience and study. It is also the part of the medical pipeline that offers the greatest opportunity for machine learning to produce a significant impact. An accurate image analysis algorithm, for instance, can free up the bottleneck caused by the low specialist to patient ratio in most geographies around the world. But for AI to be successful, three facets of the data challenge - scale, accuracy and cost - have to be resolved to train models to reach their full potential.

The sheer volume of medical data presents a challenge to scaling. A single MRI, CT, PET, or ultrasound scan generates thousands of images, and up to 80% of a radiologist's time is spent going through each image one at a time and organizing the findings. However if experts like radiologists, cardiologists, or pathologists have to work on segmentation and labeling of datasets with hundreds of thousands of images for the purpose of teaching algorithms, the same bottleneck becomes further aggravated. Using medical experts to label the data also quickly escalates the expense of the operation and the cost of building a viable product.

In recent years, micro-task based crowdsourcing has been used as a large scale, low-cost solution to this problem. As the online gig economy has picked up in popularity, a digital-savvy workforce that can be assigned repetitive labeling and annotation tasks has been created. Complex tasks are disassembled and assigned to online labelers, and then reassembled to create the completed package. While this addresses the scaling issue and provides access to a 24/7 workforce, accuracy and consistency can be stumbling blocks. Consistent quality control in particular is crucial as inconsistent interpretation of the medical data may have very real patient outcome consequences.

In leading the Medical Division at iMerit, this is where I've witnessed robust training and knowledge sharing models make a significant impact. Through specialized training, the expertise gained by medical professionals through years of practise can be transferred to a dynamic workforce with the right skillset, wherein pattern recognition and memorization abilities are leveraged to handle medical data at scale. In essence, this creates a new field of experts in specialized medical data labeling that is defined by narrow scope, specific context, and deep subject understanding. Such a model equips data labeling experts to contribute to massive medical data labeling projects. This provides a sustainable skilling model that can handle data at scale, helping game-changing medical applications go from the R&D stage to commercial use as well as providing life-changing opportunities for a work-force.





To tackle the skilling challenge, our first step is to develop a curriculum based on understanding medical lexicon, pathology, spatial orientation, and data manipulation. Just as in medical school, we also get a sense of who is curious about learning about the body and who is turned off from exposure to graphic medical images. Project-specific training includes live-demos, videos, models, and instruction guides.

There are several advantages to partnering with a dedicated inhouse workforce. The secure environment helps customers manage their data pipeline with confidence. Once the project is underway, a continuous and iterative review process takes place, particularly while dealing with tricky edge cases. Large volume data

## THE TECH PERSPECTIVE

exposure combined with expert supervision then provides insights to long-tail problems and obstacles. Lastly, a multipass workflow ensures the degree of precision and accuracy necessary for medical applications. Labelers gain further expertise by expanding their understanding to new modalities and pathologies over time.

Equipped with specialized knowledge and a trained eye, a medical data annotation expert team is able to focus its attention entirely on identifying abnormalities in images, slides, videos, and other datasets. A day's work is spent dealing with thousands of anatomical images with extreme concentration, but in talking to the team, I've found this motivates the team as they are compelled by the valuable use-case and the endless variations in the data.

Data labeling experts like Namita Pradhan and Chinmayee Swain, who were initially recruited for their eye for detail and accuracy, have now become deeply interested in the subject matter. Namita talks about reading medical material on her own time to prepare for potential use cases where her data labeling skills might be leveraged.

Another contributor, Chinmayee talks about the pride in her work and connects her work as some day helping her own community meet its healthcare needs. Being fairly compensated for their skilled work and thriving in a collaborative work environment also increases the investment of each employee while undertaking projects of this complexity.

The human intelligence that we need for medical AI to work is distributed equally across the world but as we all know, opportunity is not. An enterprise skilling model bridges the gaps, both with expertise and access, and enables a global workforce to participate in the development of cutting edge technologies. Specialised data workers can ease the burden of doctors just like paramedics and nurses do in their areas of expertise.

### BIOGRAPHY



**DR. SINA BARI** is a Stanford-trained surgeon and Medical Director for iMerit where we help companies create high quality ground truth data to train AI models.







# LEGAL EYE ON AI

Because technological advancements outpace legal ones, there are no AI-specific laws upon which physicians can refer to for a definitive answer

**A**lready a multi-billion dollar industry, the healthcare artificial intelligence market is expected to grow to \$36.1 billion by 2025. This expected growth is unsurprising. AI has seemingly infinite applications in seemingly infinite clinical situations because it can, among other things, be used to detect meaningful relationships within data sets to diagnose patients, treat them, and even predict disease. In some areas, AI is already capable of matching, and at times exceeding, the performance of an experienced physician.

But errors are inevitable. Even with AI. And while AI's use is increasingly widespread, its use is still in its relative infancy, creating many unanswered questions. One such question is the impact of AI on liability. When an AI-assisted decision proves wrong, who is responsible? Is it the company that developed the AI? Or is it the physician that used the AI to assist in making the ultimately erroneous decision?

Because technological advancements outpace legal ones, there are no AI-specific laws upon which physicians can look to for a definitive answer. Determining who bears liability for an AI-based-erroneous decision requires an understanding of: (i) AI's role in the erroneous decision; and (ii) the resulting error.



## SCENARIO ONE: PHYSICIAN'S ERROR

Suppose a physician uses an AI-based program to help detect tumors. The program identifies which patient's MRI is likely to indicate the presence of a tumor. The physician then reviews only those identified MRIs to make the ultimate decision of whether a tumor exists. The program identifies a tumor in an MRI. The physician reviews the MRI, but erroneously concludes that the MRI does not in fact identify a tumor. The patient's tumor goes untreated and that patient dies.

In Scenario One, the error appears to fall squarely onto the physician. The presence of AI, therefore, does not materially change the liability analysis; AI is a tool, intended to assist the physician's decision-making, not supplant it. Indeed, the AI worked as programmed—it correctly identified the presence of a tumor. The physician will likely be liable for medical malpractice, provided that the physician's use of the AI deviated from the recognized professional standard of care, which would appear likely.



## SCENARIO TWO: AI'S ERROR

Now suppose a physician uses the same AI-based program to help detect tumors, but the program fails to identify a tumor in an MRI. Consequently, the physician never reviews the MRI, the patient's tumor goes untreated, and as a result that patient dies.

Scenario Two presents a more challenging analysis. The erroneous decision—the presence of a tumor—was not based on the physician's decision but on AI's. Whether the physician will face medical malpractice liability depends on whether the physician's process—not reviewing certain MRIs—comports with the professional standard of care.

This is not an easy question to answer. Because of AI's relative infancy in the healthcare profession, there are few, if any, established standards involving AI. And, if AI has at least equal accuracy to an average doctor, it seems difficult to establish physician negligence (and it would appear unjust to do so). After all, is that not what the AI is for?

The AI's creators will likely incur liability, under a products liability theory, because the AI proved defective. AI itself, of course, cannot be liable for an erroneous decision; as it is not a recognized entity that can be sued.

There is a remote possibility that the AI's creators could face medical malpractice liability. Such liability will be difficult to establish, however, because most states, including California, have laws that prevent a company from practicing medicine. This doctrine encapsulates the principle that physicians must make decisions autonomously. The corporate practice of medicine therefore precludes any entity other than the decision-making physician from incurring medical malpractice liability for an erroneous AI-based decision.



## SCENARIO THREE: UNFORESEEN ERROR

In Scenario Two, the AI-based error was a foreseeable one: the AI was designed to detect a tumor and failed to do so. What happens if the same AI program creates an unforeseen error?

Now suppose a physician uses the same AI-based program to help detect tumors. However, for each MRI that the AI identifies as being likely to reveal a tumor, the list of medications to which that patient is allergic is deleted. As a result, a patient whose MRI revealed the likely presence of a tumor, was prescribed medicine to which he was allergic, causing him harm. Scenario Three creates an even more complicate analysis. It would appear difficult to hold the physician liable for a computer error. Whether the

physician will be liable for medical malpractice depends on whether the physician's decision not to review the prescribed medicine violated the standard of care.

Whether the AI's creators are held liable is also a complicated question. Their liability will depend on whether AI is held to a strict liability standard (i.e. no fault) or a negligence standard. If the latter, the question will be whether the AI's deletion of the patient's list of allergic medicines was foreseeable to the AI's creators. If not, it will also be difficult to hold the AI's creators accountable under this scenario.

AI's increased use in healthcare will create more legal questions than answers in the short-term. Overtime, however, new standards will develop that should help to add clarity to the inevitable pervasiveness of AI in healthcare. ■

## BIOGRAPHY



**KAMRAN SALOUR** is a Senior Trial Attorney and Certified Information Privacy Professional (CIPP/US) at Callahan & Blaine, APLC. Kamran creates solutions for his clients, who range from individuals in familial disputes, businessmen in business disputes, and companies seeking data privacy compliance advice. He is also a proud AI Med Ambassador.

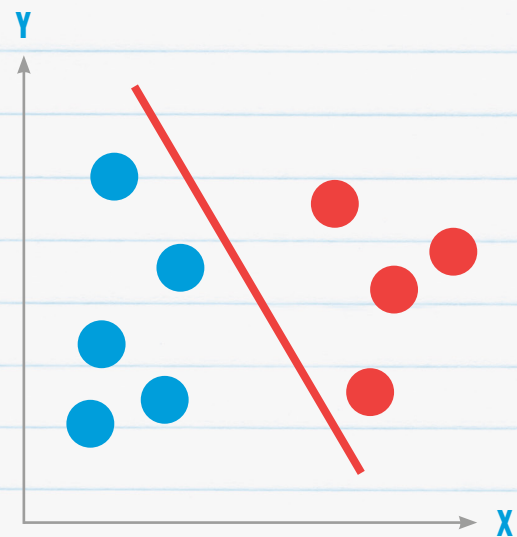


## SANDEEP EXPLAINS...

## “WHY IS SUPPORT VECTOR MACHINE (SVM) A POPULAR MACHINE LEARNING ALGORITHM IN MEDICAL DATA ANALYSIS?”

**T**he SVM is becoming a popular machine learning algorithm to use when it comes to predictive analytics and diagnosis in medicine. While in non-medical disciplines, artificial neural networks have overtaken SVMs in popularity, SVMs continue to be widely used in machine learning driven medical data analysis. What is the reason for SVMs popularity in medicine? Unlike neural networks, SVM models have no hidden layers that can't be audited, can work on small datasets and, in certain cases, comparable levels of accuracy to that of neural networks.

An SVM is a supervised machine learning algorithm, which can be used both for classification and regression purposes. The current version of SVM was developed by Vladimir Vapnik and Corrina Cortes in the early 1990s. SVM works differentiating data items (support vectors) into two classes through a hyperplane (separating line) as illustrated in the below diagram. The further away the data items from the hyperplane the more confident one can be about the accuracy of the classification. The versatility of SVM is that it can be used for non-linear classification and even unsupervised machine learning classification (when data is unlabelled). In addition to classification, SVM can be used to build regression models i.e. prediction of outcomes based on medical data analysis.



Because of the simplicity of the algorithm and its ease in being able to analyse data it has been used in a wide variety of medical scenarios successfully including prediction of medication adherence in heart failure patients, predicting factors affecting preterm delivery, diagnosis of cancer conditions, prediction of development of dementia and diagnosis of schizophrenia. SVM has also been used to classify medical images. SVMs have great accuracy and can work on small (but clean) datasets. However, they aren't suited for large datasets and unstructured datasets with overlapping classes.

**JULIE COLLENS**  
PhD

Established by

**2015**

Founded

**SAN DIEGO,  
CALIFORNIA**

Headquarters



# SWIMMING WITH THE SHARKS

**AI MED:** Congrats on winning the AIMed 2019 Shark Tank! At what point did you realise you weren't going to get eaten alive?

**JULIE COLLENS:** There were several very strong companies who were part of the competition, and a very strict time limit, so any blood in the water could have been trouble. The companies who went before me received good, constructive feedback -- and the judges asked great questions -- so the pressure was off once I realized it was going to be a great experience either way.

**AI MED:** Did you enjoy the AIMed conference? Did you have any meaningful conversations with fellow attendees?

**JC:** There were a lot of interesting discussions and themes on how human error is being mitigated by data-driven approaches, yet there is still a tendency for physicians and caregivers to trust their own judgment over these approaches -- even where the data shows clear improvements in healthcare delivery. Machine learning and AI are powerful tools to look for signals in otherwise overwhelming and disparate pieces of data, and I was encouraged to see entrepreneurial physicians at the conference driving the innovation and supporting the implementation of such approaches.

**AI MED:** Can you explain briefly the mission behind Vivid Genomics?

**JC:** The mission of Vivid Genomics is to accelerate neurodegenerative disease drug development by identifying individuals who are most appropriate for clinical trials. We are using a strong understanding of disease biology and genomics, and applying machine learning to develop genetic-based tests to identify

variation among clinical trial participants. We're starting with tests for Alzheimer's disease trials, since the unmet need is so great. Beyond our initial tests, our vision is to identify all subgroups of Alzheimer's disease and other dementias. Having information about variation in clinical trials helps pharma companies design better trials, which accelerates enrollment, reduces costs, and improves the probability of clinical trial success. There are promising drug candidates now, so when companies are able to enroll the right participants in clinical trials for those drugs, that's when we'll see what the drugs can really do, and we believe this will ultimately lead to a drug approval in Alzheimer's. This precision medicine approach is now the standard in the field of oncology for cancer drugs, and we believe what we're doing represents the future of neurodegenerative disease drug development.

**AI MED:** Do you feel the tide might be turning for Neurodegenerative Disease like Parkinsons and Alzheimers?

**JC:** Alzheimer's disease is notorious for drug failures. There have been more than 150 failed attempts over the last 30 years, and yet with 50 million people worldwide affected today and the global trend of aging populations, the unmet need is enormous. And while some drug companies have announced that they are walking away, many others -- like Novartis, Lilly, and Biogen -- are doubling down, and these and many early stage companies are taking novel, innovative approaches to addressing the disease. There is definitely a trend away from "all-comers" trials, and a realization that targeting the disease early on and in patients whose disease is less advanced will likely be more successful than trying to address the disease once the damage has been done. Just as it doesn't make sense to give statins to someone after they've had a heart attack, these drugs are likely to be more





beneficial before major changes have taken place in the brain. That makes it more challenging to identify appropriate clinical trial candidates at earlier points in time, and that's why we believe genetics are so powerful. I think with new tools in place to identify patients earlier and understand what's driving their disease, pharma companies will have a better chance of seeing efficacy of their drugs in trials, and that will ultimately lead to drugs getting approved.

**AI MED:** AI will clearly play a fundamental role in guiding precision medicine but how important is a multi faceted approach in tackling such a complex area of disease?

**JC:** AI is only useful if the application is well-defined. Understanding the biology of disease is critical, and integrating multiple kinds of clinical and genetic data allows us not only to better understand the disease, but to use and apply genetic information in a useful way.

**AI MED:** What are Vivid's goals for 2019?

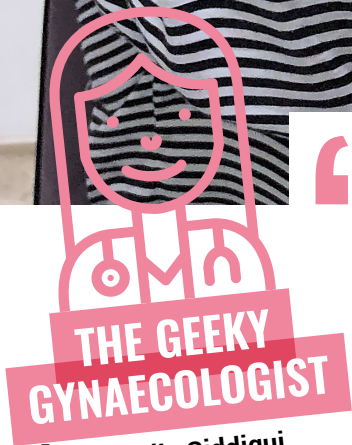
**JC:** Our goals for 2019 are to hire three more rockstar scientists, complete an external validation study demonstrating the performance of our machine learning pipeline, run a pilot study with our first pharmaceutical partner, and commercialize our first two tests. And to secure the \$2.5M to make this happen.

**AI MED:** Are you an advocate for sequencing patients with a family history of neurodegenerative diseases?

**JC:** In a research setting in the context of very large data sets, yes. Under those circumstances, sequencing data from patients with a family history of neurodegenerative disease is very useful. There are a number of large genetics consortia who are doing exactly this, and it benefits our understanding of disease. For familial, early-onset Alzheimer's disease, there are a handful of genes that are very penetrant, or predictive, of one's likelihood to end up with disease. However, for late-onset Alzheimer's and other complex diseases, environment still plays a role, and even with a certain genetic makeup, individuals may live long and healthy lives. I think it's a personal choice for someone to determine whether they would like to know their risk.

**AI MED:** Do have any advice you'd give burgeoning start ups in the field when pitching their technology to investors?

**JC:** It's a little like high school - not everyone will understand you, and maybe not everyone will like you, but if you're honest, know your value, and keep having conversations, you'll find your people.



**Necessity is the mother of invention.** PLATO

Critics will state that in any time frame, good practice in medicine is to ensure that all efforts are focussed on the best outcomes for the patient in the most empathetic manner with highest standards of care.

# DIGITAL DRAGGERS VS DIGITAL DISPERSERS



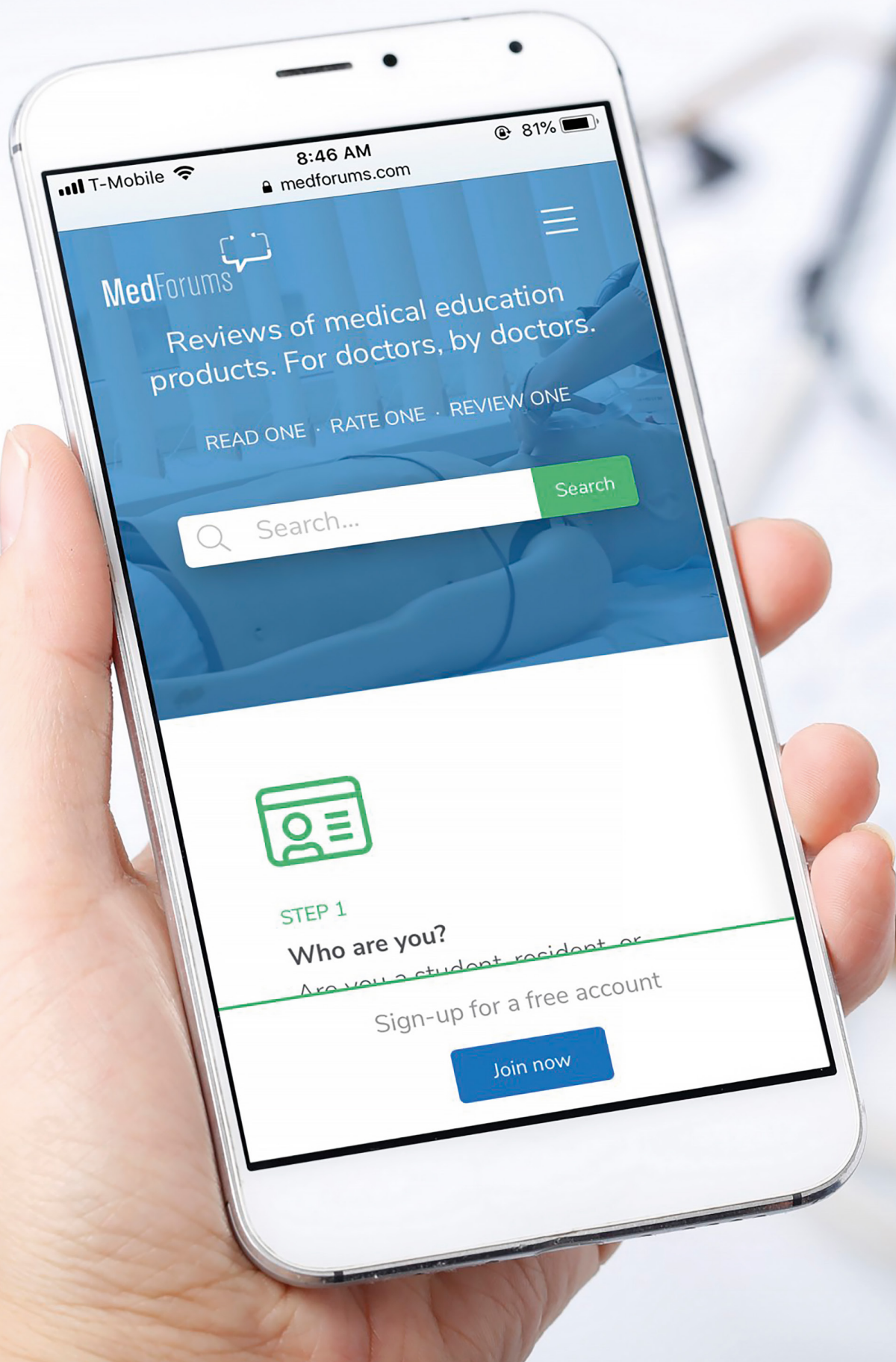
**M**edicine is the field of health and healing. As the practice of medicine evolved over centuries, the development of the prevention and treatment of disease from prehistoric and ancient times to the 21st century has shown a transition from almost barbaric practices, as late as the 1850's, to a period of slow transition towards discovering newer, more effective methods of medical treatments. In these transitional periods many physicians and surgeons, hesitated to use new ways of doing things. One of the main barriers to adoption was fear of loss of reputation which made the majority of them hang on to age-old practices, doubting the effectiveness of such advances.

Ironically, here we are amidst the age of digital disruption, at the cusp of the fourth going into fifth industrial revolution, yet we still find variation in the innovation to adoption to dispersion cycle. It's interesting to note that the net and digital generations are being checked back in many instances by the baby boomers who can almost be relabelled as digital draggers. It is the inertia to change and the fear of leaving set practices for new ways of doing things that forms a barrier in such cases. In medical practice, one often hears the phrase that in the good old days we used to do things 'the right way'. The right way may have been the best way at a particular time but may not be the most effective, efficient and patient friendly method in current times. Needless to say, the current way may not be fit for purpose in future settings when there may be another solution that is more appropriate for the needs of that time.

Critics will state that in any time frame, good practice in medicine is to ensure that all efforts are focussed on the best outcomes for the patient in the most empathetic manner with the highest standards of care. For them anything that may seem to be between the physician and the patient is not the right way. The thought of using telemedicine in care homes may be unpalatable. The idea of Big

Data generated algorithms behind applications enhanced with Artificial Intelligence, prompting the most appropriate next step in patient management, is an insult to the years spent in medical college and years of clinical training. Relying on machines to make decisions has to be an opt out from the hierarchy of cognitive supremacy of an expert in his field. This mind set is a real challenge to the early adopters. One overwhelming factor which has never been seen before is the speed of change. Often this becomes an embarrassment, by the time one has finally won some ground amongst the organisational diaspora to accept the change, there is another solution, better than the one before, on the horizon.

It is imperative for the digital dispersers to win over the resistance through good evidence and demonstration of how the new way is better for the patients. The additional financial arguments are more relevant while pitching a business case before the commissioners. Terms like precision medicine, predictive medicine and preventive medicine using Artificial Intelligence may create a blur of all good things but not exactly convey a clear understanding of the concepts. Clarity in simple words stating the need, the innovation, the process of adoption and rolling out or dispersing (scaling) the solution is key to win over the hearts and minds of the resistors who may be among the decision makers or the end users. A solution is only as good as its up take by the end user in most cases. Finding a few champions amongst the end users acts as a catalyst in energising the transition process. Another important way is to give real examples from the day to day workings and hurdles faced by the end user to win the support of trying another way of doing things. The real challenge comes when it is said, 'we have seen this process of change before and it's no use'. To tackle this requires the expert skills of motivational leadership and a patient process of the wheel of change cycle to take its course. ■



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## DR. JOHN DAYTON

University of Utah

Dr. John Dayton is versatile. If you ever have a chance to read his email signature, you will get a glimpse of the many hats that he is wearing right now. Primarily, he is an emergency physician, at the same time, he is also an adjunct professor for University of Utah, past president for Utah's College of Emergency Physicians, co-founder of Utah's chapter of the Society of Physician Entrepreneurs, and founder of MedForums.com, an online medical education and resource portal.

# THE EMERGENCY PHYSICIAN WHO WEARS MANY HATS

**N**evertheless, he remains humble and laughed when asked about his career choice, calling it "a different niche". AI Med caught up with this multi-tasker and found out how he is able to juggle between these vastly varied roles, his newly established online forum and his views towards artificial intelligence (AI) and emergency medicine.

**AI MED:** As an emergency physician, what are some of the benefits AI or new tech can bring into the emergency ward or the field of medicine?

**DR. JOHN DAYTON:** I am glad you asked this. One of the biggest problems in emergency medicine is planning. We need to figure what to do when there are surges of patients and when there are not as many patients as expected. It is a constant balance between over-staff and under-staff. Thus, the AI-driven predictive model can help.

Besides, sometimes there are things in the community, such as drug abuse, a Hepatitis A outbreak caused by food, or an influenza, where predictive models and networking between different hospitals can really help to focus our attention. That's why, I think there is a huge area that AI and new technology will benefit. I feel there is a nice mix where all information can come together.

Some of the companies I met at the annual emergency medicine conference, are able to use deep learning and predictive models to shorten an acute patient's time in an emergency room (ER) by an hour and a non-acute patient's time in ER by less than half an hour. So, there is a greater efficiency here; more people can be treated and we can better make use of resources. Things like this make me excited about what AI can do to emergency medicine. ▶

**AI MED:** Unfortunately, some people are still very skeptical about new technology. For example, when electronic health record (EHRs) was introduced, we thought it may make medical documentations more structured but over the years, healthcare professionals expressed their disregard. In your opinion, do you ever think it may be the case for AI and new technology? How do we instill confidence in people?

**JD:** I don't think the problem lies in EHRs but the EHRs that we have created. EHRs these days behave more like a "cash register", physicians are providing all the input on top of making medical decisions. Often, physicians feel that they are spending more time on EHRs rather than providing care for their patients and this is frustrating.

On the other hand, we need to look at the positive side of EHRs. Before EHRs, physicians had to pen down all the information, we had to be able to read other physicians' handwriting, and not many of us can write legibly. But with EHRs, I can pull up an old electrocardiography (EKG) and compare it with the current one. By reading the record, I know of the patient's recent hospital visit, I can read the operation report from primary doctor; I have a much more holistic view of what is going on with the patient and this enhances care. If, I work on a night shift, for example, it's impossible for me to get information from someone in the middle of the night, so EHRs are essential.

I think we should look at AI the same way too. We recognize that if our goal is to do something more efficiently, especially for emergency physicians, and to make sure that we are doing things according to protocols, I think AI is going to give us a lot of benefits.

**AI MED:** There are many AI-healthcare startups in the industry these days, as a physician, do you ever feel overwhelmed or pressured to adopt something new into your workflow?

**JD:** Not yet but I can relate to this. It is like adopting a new medication. There will always be the first doctor who is cutting edge and tries it. On the other hand, there will be the conservative ones who are not quite ready to use the new medication until there's more literature about it and many are more familiar with it. I think people will share the same mentality for medical technology.

**AI MED:** What are some of the considerations you exercise when bringing AI into your workflow?

**JD:** The big things I will consider are: what data is available? What kind of experience do people who have used it have, can I chat with them to find out more and the kind of feedback they have with the technology? The other thing is cost. The best EHRs, are epic, but also astronomically expensive. Hence, if I were working in a small hospital, the high cost may not necessarily outweigh the benefits of the hospital that is using it.

At the end of the day, I think most of us physicians, need data and feedback

that we can trust, not from the company's sales representatives but from colleagues who have used it. We want to ensure that the new and shiny technology which intrigues people, is good for medicine and is good for our patients.

**AI MED:** As a professor, do you think this is a good time to integrate AI into the medical curriculum even though there are already a lot of things that a medical professional needs to learn; are we being practical to ask them to learn even more?

**JD:** This is an interesting question. One of the things happening in Northern California schools, is that they are experiencing a situation whereby many medical students foresee it takes time and effort to get into medical school and practicing, which may put them off pursuing this as a career choice.

So, many of the medical technology companies are starting to lure these excellent students or residents away into digital health, with promises of a better lifestyle. There is a fear that the demands of medicine and physician burnout, may actually drives some of the really good, potential pupils and practicing doctors into the technology field.

I think we probably need to get to a point where we can incorporate technology into medical school, to reduce the risk of losing potential new students to this field.

**AI MED:** Indeed, we have read so many negative statistics about physician burnout but in actual settings, in the ward itself, how bad is physician burnout?



**JD:** It is one of those things that people don't talk about. In the past when people felt bad about their work, they likely to met it with the kind of old school attitude: you are just not working hard enough, you know you need to tolerate a little and do what you need to do. However, there are numerous physician suicides, many are transiting out of what they are doing alongside those who are ending their career earlier that they wanted, just because they are fed up.

By looking at the statistics, I think we have passed the old mentality of all you need is to work harder and everything will work out. I believe we are at a point where if you really have concerns, be it because of the hospital you are working for, or you are being forced to do something unethical or something that feels like your rights have been abused, they can become rather detrimental.

**AI MED:** Would you please tell us more about MedForums.com, the medical education and resources portal which you founded?

**JD:** One of the things that motivated me to start the forum was physician trust among their peers but at the same time, we are overwhelmed with advertisements. Things like board or licenseship examinations can be quite stressful, especially as there are many different options that you can use to study with each of them costing up to a couple of thousand dollars. There is a need for a huge time commitment, in order to get the best result.

So I started MedForums.com last October, to help my fellow colleagues find the best medical education. Colleagues can rate different courses that they have undertaken for CMEs (continual medical educations)

or any online modules or podcasts that they would recommend or that might be beneficial. I see this as an expansion from the "FOAMED" movement. "FOAMED" began as a hashtag on Twitter, meaning "free online access to medical education".

Most of the time, when a textbook comes to the market it is almost outdated, or by the time you know of a research result, it is going to be a couple of years before it gets adopted. So, the FOAMED movement is a way to get people bringing information out a little quicker. What MedForums.com does is to highlight the best blogs, podcasts or other source materials that physicians need for training. Presently, we have about 12,000 users and it's exciting to see people coming on board every day.

**AI MED:** Going back to yourself, what are some of the significant differences between being a physician, professor, healthcare leader and founder?

**JD:** I feel like as a physician, the old philosophy was to take care of my patients and as long as I work hard, society will somewhat take care of me and things will happen according to my interest. I don't think this is the case anymore. Healthcare is becoming more complex. While I continued to advocate my specialty and care for my patients, I am also interested in knowing and adapting new technology that is most helpful for patients, that's why I started writing about it. I feel like it is the best way to spread information. It's a great experience to work a 12-hour shift and to be able to save lives, but I feel advocating the policy and bringing in new technology will help on a larger scale.

**AI MED:** So, do you have any recommendations for anyone who wants to be like you but is unsure where to start?

**JD:** When I was in medical school, we were told to find something that makes you unique in your special area, because that makes us excited to go to work. So, some of us chose to become expert in Ultrasound, some in radiology or cardiology etc. I think in general, a way to avoid burnout is to make yourself excited about work. ■

# BOOK

REVIEW

## SOLOMON'S CODE

OLAF GROTH & MARK WITZBERG

After a year of artificial intelligence (AI) hype, most would ardently welcome a reality check in the form of an erudite yet relatable book. Such a book, titled after the Biblical King Solomon who embodied wisdom, has arrived and is a timely work on an overall perspective on AI and humanity in this current era.

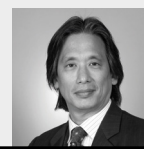
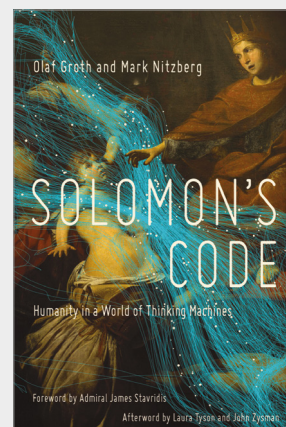
Olaf Groth, the Hult International Business School professor and strategist, and Mark Nitzberg, the executive director of U.C. Berkeley's Center for Human Compatible Artificial Intelligence, joined forces to author *Solomon's Code: Humanity in a World of Thinking Machines* (Pegasus Books, New York, 2018). With the aforementioned quote as a central tenet to focus on AI and humanity's intertwining conceptions of values, trust and power, this book covers a wide range of spheres including medicine (such as IBM's Watson and its role and deep learning and its capacity for pattern recognition) as well as the legal system (LAPD's Minority Report-esque predictive policing system).

The authors delineate the significant present the myriad of challenges of AI including furthering the digital divide and introducing automation bias and complacency (from not having to remember or even think as we cede these activities to machines). In addition, there is the "black box" aspect of AI that renders it difficult to understand and therefore breeds mistrust

and distance amongst stakeholders. Lastly, an Orwellian concern of ubiquitous surveillance and AI is China's proposed social credit initiative with a system based on social behaviors, including good ones (such as helping the elderly or donating blood) but also relatively minor unfavorable ones (such as being drunk or failing to stop at stop signs).

While the authors attempt to have a balanced perspective on AI between the hype and the doom with its moral and ethical implications, they tend to lean towards the positive in their projected outlook. The prime example of this relatively anthropocentric view is the authors recommendation to draft a "Magna Carta for the Global AI Economy" by a global oversight body to assure AI safety and justice. One of the most challenging aspects of such an audacious vision for universal regulation is, ironically, organizing humans to collaborate and execute such a utopian vision.

Overall, this is a thought-provoking introduction for anyone (even the AI neophyte) who is ready for a concise and clear overview on the current state of the art of AI around the world. Just as King Solomon, who succumbed to his flaws and was therefore doomed in his quest to achieve greatness, this book serves as a cautionary tale for us to safeguard AI as our new exciting resource.



### REVIEWER

**DR ANTHONY CHANG, MD, MBA, MPH, MS** is the Chief Intelligence and Innovation Officer and Medical Director of the Sharon Disney Lund Medical Intelligence and Innovation Institute (MI3) at CHOC Children's. He is the Chairman and Founder of AIMed.



## CHAT WITH THE AUTHOR



### OLAF GROTH - CO-AUTHOR OF SOLOMON'S CODE

**AI MED:** What was the inspiration to write Solomon's Code?

**OLAF GROTH:** Mark and I first considered writing the book two years ago, when we were struck by all the hype growing around the latest wave of artificial intelligence. We were seeing all these utopian or dystopian scenarios – usually thinly supported fantasies of what the world would look like 50 years from now. We both felt that overhyping AI was the best way to lead us into another AI Winter, during which interest and investment in research would recede as our hunger for The Next Big Thing went unsatisfied. Worse yet, we felt all that buzz obscured for more critical conversations about the opportunities and risks that AI is already posing and will pose over the next 10 to 20 years. Machine learning, deep learning, heuristics and other cognitive-computing applications hold tremendous potential not just for economic growth, but human and societal growth, as well. We need to keep funding AI research so we can both capitalize on its potential and mitigate its risks, and we do that by collectively developing the proper ethical and human-centric governance models.

**AI MED:** The biblical King Solomon referenced in the title learned from his mistakes. Is there anything you'd do differently when writing the next book?

**OG:** We would put more emphasis on jobs and the future of work. When we first started writing Solomon's Code, that conversation was just beginning. It has blossomed since then. People are afraid to lose their jobs, and some of the threats are real, but not in ways most people imagine. There won't be a one-to-one displacement of human labor by bots or robots, but most jobs will see many of their individual job tasks reshaped or divvied out in different ways. We're transitioning to an era of truer symbio-intelligence, as we call it. We will need to adjust to a more complementary partnership between humans and machines. And, as in every partnership, roles will change. That's a seismic shift, and it will come faster than societal institutions can adjust with training programs and the like. Especially in the U.S., we're not doing much to prepare people for that.

**AI MED:** Were your belief systems on AI the same before and after writing Solomon's Code?

AI can help with optimization of complex systems of systems, especially when it's paired with quantum computing, another "deep tech" trend we see emerging over the next decade. Through sophisticated simulations, these technologies will give us deeper and deeper insights into the human body, diagnoses and treatment paths, as well as the economics associated with these and other treatments. ”

**OG:** On one hand, yes, in that both Mark and I have always believed in the power of business and technology for positive and responsible social change. We believe even more strongly today that responsibility, ethics and AI are inseparable. But on the other hand, our beliefs have changed somewhat. We have come to see even greater potential in AI after talking with so many brilliant researchers. Our minds have been opened to many more global influences from innovators everywhere. Through our set of 100-plus global interviews, we have seen science and applications that are mind-boggling – Israeli entrepreneurs using neural networks to alleviate brain injuries or a Filipino startup using image recognition to detect eye problems through smart phones and then connect people with needed care. When you find all these great examples you realize that we need to reframe the conversation – we need to understand that we also have an ethical responsibility to pursue AI for good. Everybody dealing with AI should recognize this as a global phenomenon and look beyond the U.S. and China.

**AI MED:** Do you think AI has the opportunity to fix a broken healthcare system in the U.S. and indeed globally?

**OG:** AI can help with optimization of complex systems, especially when it's paired with quantum computing, another "deep tech" trend we see emerging over the next decade. Through sophisticated simulations, these technologies will give us deeper and deeper insights into the human body,

diagnoses and treatment paths, as well as the economics associated with these and other treatments. We almost certainly will find new biochemical compounds and more personalized medications. This would increase the efficacy of healthcare applications, but it would also help alleviate the bad politics that come into play when powerful interests exploit elevated levels of ambiguity and uncertainty in medicine and the healthcare system. But this all depends on who controls these technologies and the data they utilize and produce. That's an especially big question in healthcare.

**AI MED:** We talk a lot about ground truth data – how do we eliminate bias and protect the integrity of the data?

**OG:** For medicine, we need to create better anonymized data pools that have been certified as "clean" by independent experts. But similar standards are needed for almost every AI application today. So, we need three fundamental things to happen: First, we need to train programmers and data scientists on biases and other current societal phenomena that are too often isolated in the domains of sociology, psychology, anthropology or philosophy. Computing needs to become a multidisciplinary pursuit, informed and cross-pollinated by a variety of social sciences and liberal arts. MIT and UC Berkeley are already moving in that direction with major investments in advanced computing programs that will open the lens to other fields of study.

Second, we need diverse, independent panels of experts to examine the data sets these companies use. These independent reviews should remain confidential, so as to not give away competitively sensitive information, but they should employ a clearly articulated and transparent standard of assessment. This review of data sets must happen before they're fed into the powerful algorithms that influence millions if not hundreds of millions of people.

Third, we need the ethics architects who are part of development teams to help assess human and societal systems impacts of new, mass-deployed and high-impact code. In essence, we need the AI equivalent of clinical pharmaceutical trials for these mass-influence algorithms, because they function like drugs for the brain and threaten the very fabric of society.



**AI MED:** Where do you see AI having the biggest impact in healthcare?

**OG:** We've already seen significant disruption in imaging, particularly radiology, and we expect those advances to continue. The ability of advanced machine learning to recognize faint signals in the noise could have tremendous effects on neuroscience and treatment for brain and nervous system maladies. The combination of AI-enhanced pattern recognition with the smart phones most of us carry around in our pockets has already produced some extremely powerful interventions for addicts and patients who suffer from mental disorders. We're seeing incredible gains in personalized immuno-deficiency and cancer treatments. And the ability to model and help us understand the complex systems of systems might eventually help alleviate some of the main cost-drivers of health care.

We talked about these and many other examples in the book, but one anecdote that really fascinated us came from a longtime AI researcher in Europe. Years ago, he and some colleagues had made a significant breakthrough in the way machines "remember" information. Today, that construct is fundamental to most AI models, but at the time it barely made a splash. So he went into pharmaceutical research. He and his colleagues recently found a way to model the effects of drug's molecular structure in ways that reveals toxic effects that pharmaceutical companies had never contemplated or imagined. It's in early stages now, but it could transform the testing process and the overall cost of drug development.

**AI MED:** Is there a cultural shift that needs to happen before we can fully embrace AI?

**OG:** People need to start trusting AI and the innovators and owners of the technologies – but those same researchers, companies and organizations need to do more to earn that trust, too. Trust is the most important and irreplaceable currency in a society and in an economy. Without it, things fall apart and technologies fail to live up to their potential. To build that trust, we need far more transparency and "explainability" about how these AI systems work, and that insight needs to be delivered to people in ways the non-technical mind can understand.

People need to understand trade-offs, and they need to know how much lower their chances of treatment success might be if they simply reject AI.

**AI MED:** Are we doing enough to consider the future legal and ethical ramifications of AI in medicine? Are we heading down an AI rabbit hole?

**OG:** Ethics is a difficult domain, because so many facets of it are subjective, culturally dependent, situational or contextual. But there are shared ethics norms between and across groups and peoples – not all is relative. So, we clearly need to do far more than we have to date. We have HIPPA in the U.S., but we need to update those regulations to accommodate many of the advances we mentioned above. We need to return data ownership to consumers/patients and truly put the human at the center, rather than the object of data-driven business models.

That's been the biggest problem: The objectification of human lives. We need to start measuring whether all this technology actually improves human wellbeing and happiness. It sounds fluffy, but it can be done. We've encountered a lot of work done on indices and metrics we can use to discern human benefit, including in terms of individuals versus the system.

And then we need to establish the new Digital Magna Carta we describe in Solomon's Code. This will serve as a precursor to a shared code-of-conduct across all our business, societal and national boundaries. It won't happen overnight, but the dialog itself will be useful. In our conversations and consultations since the book was published, as well as in public announcements by some large corporations, we're seeing more evidence that leading companies are willing to put stakes in the ground and commit to a human-centric, ethical and fair approach to AI development. It might just become the big competitive differentiator.

**AI MED:** What did Elon Musk think of the book?

**OG:** We haven't heard from Elon yet, but if you do, please let us know!

## Article

## HIGH- PERFORMANCE MEDICINE



**O**ur article of the month was written by Eric J. Topol a renowned influencer in digital medicine and founder and director of the Scripps Translational Science Institute. We asked him a few questions surrounding the themes discussed in his thought provoking article.

**AI MED:** I thoroughly enjoyed your article in Nature Medicine. Would it be fair to say that you're cautiously sanguine surrounding AI and its future promise?

**ERIC TOPOL:** Yes, I think the potential is remarkable but we're very early on and there's no shortage of caveats and challenges.

**AI MED:** Do you think as a rule the Industry adopts enough pragmatism and considered foresight around AI and its application to medicine?

**ET:** Yes, we need that and a lot more prospective validation in the real world, clinical environment, along with implementation studies and continuous surveillance.

**AI MED:** Have you any insight as to why pathologists have been slower to adopt AI than radiologists?

**ET:** Yes, because they have not really gone digital with Whole Slide Imaging

(WSI) which is expensive and requires a big upfront investment.

**AI MED:** Do you fear that we have a tendency as an industry to take the path of least resistance and sometimes avoid the complex and difficult issues?

**ET:** Yes, that is always the case. But here the stakes for both benefit and potential harm are much greater.

**AI MED:** Why do you think there aren't enough peer review submissions and prospective studies in this field to date?

**ET:** It's early and they will certainly come along. But many are coming from computer science circles who submit to preprint platforms like arXiv and don't necessarily follow through with submission to peer review.

**AI MED:** Clinical Utility is fundamentally important when assessing an AI application but it's often said that the usability of the technology is often overlooked. As a cardiologist what is your opinion of the AI driven cardiology devices that are on the market?

**ET:** There aren't many yet. There are imaging algorithms like MRI and FFR and smartwatch ECG for atrial fib. But that's very limited to date.

**AI MED:** Healthcare Disparities in the healthcare system are irrefutable. Can you talk about what recommendations the Topol Review has made for the NHS in using AI in a positive way to reduce inequities in healthcare delivery for the vulnerable and disadvantaged?

**ET:** We could make the situation far better or worse, depending on how this plays out. We're talking about cheap chips and software, which could be given away, especially to those who cannot afford these technologies. If this turns out to be an access for affluent only story we have totally blown it.

**AI MED:** Ultimately we need a cultural shift in thinking around AI. How important will leadership and education be in delivering high performance medicine to the masses?

**ET:** Critical, or course. That's an advantage of NHS which has a big Education wing to it. Nothing like that in the US.

## REFERENCES

## 01

High- performance medicine; the convergence of human and artificial intelligence. Mature Medicine Vol 25 January 2019 44-56



# EXECUTIVE SUMMARIES

Our longer features broken down into takeaways

## P 8 - 11

### TACKLING THE GLOBAL CHRONIC DISEASE BURDEN THROUGH ARTIFICIAL INTELLIGENCE

By Dr Sandeep Reddy

- Response to chronic diseases remains inadequate. Often, patients are not receiving effective treatments and support to ensure a better health outcome.
- Health data accumulated from wearables, smartphones and electronic health records is now used to formulate machine learning algorithms that are able to identify at-risk patients or implement targeted interventions to prevent hospitalization and readmissions.
- Of all, diabetes and cardiovascular disease are the two most costly and prevalent chronic conditions in US and thus, create a precious opportunity for AI.

## P 14 - 19

### DIGITAL HEALTH AND AI IN RWANDA

By Joanna Ashby

- New technology allows Rwandans to have better access to healthcare as doctors are able to collect data from health activities and communicate with colleagues about a diagnosis.



- The country's first ever surgery-themed innovation workshop was conducted in December 2018 to highlight the core problem of the lack of safe surgical care resulting in preventable deaths and how technology can help to overcome this challenge.
- The lack of medical expertise in the country continues to pose challenges, but there is an active effort to seek collaborations and host events of similar nature in near future.

## P 20 - 25

### AI: THE HOPE FOR INDIAN HEALTHCARE SECTOR?

By Mayur Saxena and Joanna Ashby

- AI is believed to be an effective measure to tackle the uneven ratio between doctor and patient, as well as to increase efficiencies of healthcare in India.
- Public sector funded health insurance and healthcare demands driven by a rising middle class, have all created opportunities for AI-based companies to create more effective diagnostic solutions and monitoring of disease conditions.
- By 2022, Indian healthcare is expected to grow to \$372 billion, with AI acting as an invisible hand to revolutionize the industry.

## P 28 - 33

### AI IN THE NHS

By Eleonora Harwich

- Some medical technology companies in the UK seem to be delivering products or services without clear understanding of the underlying issue faced by the workforce or patients.
- Even if the company focuses on solution first, rather than tech,



it will still run into other barriers which prevent its scaling; a model trained in location A may not fit into the demands of location B.

- Coupled with the challenges coming from data sharing and inequalities between each health service trusts, there seems to be a long way to go before the UK can achieve its goal of being at the forefront of AI.

## P 36 - 39

### IT'S ALL ABOUT THE GROUND TRUTH

By Dr. Sina Bari

- The ground truth of training AI does not only lie in structured data but also in the human intelligence behind it.
- However, the sheer volume of data coming from various sources is posing a new challenge upon scaling. Micro-task based crowdsourcing has emerged to provide large scale and low cost solutions.

- In spite of this, there is still a need to pay attention to understanding the medical lexicon, pathology and data manipulation. With that, tech companies are advised not to work alone without medical expertise.

## P 40 - 42

### LEGAL EYE ON AI

By Kamran Salour

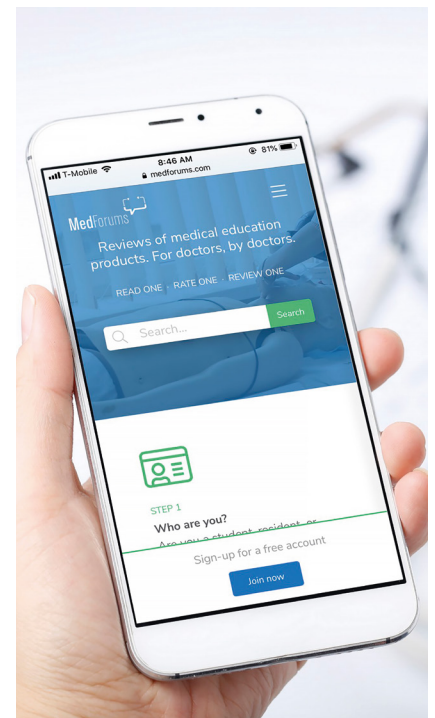
- Technology advancements outpace legal ones, so there are currently no AI-specific laws upon which physicians can refer to for a definitive answer.
- Nevertheless, an AI-based erroneous decision may likely be caused by the physician, the AI itself or an unforeseen circumstance.
- Either way, it is important to understand AI's role in this erroneous decision and the resulting damage caused by the error, before addressing the liability.

## P 48 - 51

### THE EMERGENCY PHYSICIAN WHO WEARS MANY HATS

By Hazel Tang

- Apart from being an emergency physician, Dr. John Dayton is also an adjunct professor, a healthcare leader, and founder of a medical education and resource portal.
- Regardless of which position he is in, he believes in the differences that AI will bring to his work, especially when it comes to balancing staff in emergency wards and predicting a disease outbreak.
- He feels that apart from data used to generate the AI model and cost of adoption, physicians are often reassured by a certain new technology after hearing their peers' recommendations.





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1. Safer and smarter based on HP Healthcare Edition products compared to other HP products as of August 2017; based on ability to be cleaned with sanitizing agents listed in the user guide, EN60601-1-2 testing, and DICOM calibration.
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