Artificial Intelligence in Healthcare – Applications, Regulations and Legal Issues

Digital Health Conference: Telemedicine 4.0
Dorsett Grand Hotel, Subang, Malaysia

20-21 June 2019

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Health Industries Leader, PwC Singapore & PwC South East Asia Consulting
NEW ENTRANTS – NEW TECHNOLOGY – NEW BUSINESS MODELS

NEW FINANCING MECHANISMS – NEW HEALTHCARE DELIVERY MODELS

Accessibility
Affordability
A+ Care
Interoperability
Integration
New entrants
Security (Cyber)
Safety

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PwC
June 2019
We are living in a more patient-centric era where patients are empowered...
...and behave as an always “on” consumer

- Expects a connected experience
  Consumers compare experiences across industries and think “if I can do that on Amazon, why can’t I do this with you?”

- Wants to participate
  Consumers expect to be able to find reviews and give feedback, have their views taken into account and collaborate with their favorite brands.

- Brings an innovative appetite
  The rapid evolution of personal technology has created consumer thirst for innovative new services and products.

- Can make smarter decisions
  Consumers are better informed than ever, which means they make smarter decisions that lead to better personal outcomes.

Image from: Vigyanix
We must reimagine healthcare

“We always over-estimate the change that will occur in the next two years and under-estimate the change that will occur in the next ten.”

- Bill Gates
Artificial intelligence (AI) bots will power 85% of customer service interactions by 2020
What doctor?

Why AI and robotics will define New Health

Updated June 2017
Figure 4: Consumers and providers are starting to embrace AI, but there is still room to increase trust

Consumers’ willingness to use services and procedures that could be performed by AI or robots

<table>
<thead>
<tr>
<th>Service Description</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>As an intelligent healthcare assistant to monitor my diabetes</td>
<td>61%</td>
</tr>
<tr>
<td>As a health coach</td>
<td>46%</td>
</tr>
<tr>
<td>To monitor my heart rate and advise treatment</td>
<td>37%</td>
</tr>
<tr>
<td>To check my heartbeat rhythm and make recommendations based on results</td>
<td>35%</td>
</tr>
<tr>
<td>To provide customized fitness and health advice based on my preferences</td>
<td>34%</td>
</tr>
<tr>
<td>To take and test a blood sample and provide results</td>
<td>30%</td>
</tr>
<tr>
<td>To replace a human as a doctor</td>
<td>22%</td>
</tr>
<tr>
<td>To advise on best treatments for cancer-based on test results, preferences and research</td>
<td>15%</td>
</tr>
</tbody>
</table>

When Will AI Exceed Human Performance?
Evidence from AI Experts

Katja Grace\textsuperscript{1,2}, John Salvatier\textsuperscript{2}, Allan Dafoe\textsuperscript{1,3}, Baobao Zhang\textsuperscript{3}, and Owain Evans\textsuperscript{1}

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Abstract

Advances in artificial intelligence (AI) will transform modern life by reshaping transportation, health, science, finance, and the military [1, 2, 3]. To adapt public policy, we need to better anticipate these advances [4, 5]. Here we report the results from a large survey of machine learning researchers on their beliefs about progress in AI. Researchers predict AI will outperform humans in many activities in the next ten years, such as translating languages (by 2024), writing high-school essays (by 2026), driving a truck (by 2027), working in retail (by 2031), writing a bestselling book (by 2049), and working as a surgeon (by 2053). Researchers believe there is a 50\% chance of AI outperforming humans in all tasks in 45 years and of automating all human jobs in 120 years, with Asian respondents expecting these dates much sooner than North Americans. These results will inform discussion amongst researchers and policymakers about anticipating and managing trends in AI.
2050s

Break through the hype: uncover the reality of AI
Ray Kurzweil’s theory of singularity – Another scary thought
As technology gets more sophisticated, digital innovations and care delivery could evolve from a HCP professional coming to the patient to detection and treatment capabilities inside the body.

**Convergence of healthcare technology capabilities**

- **2010**
  - Improved Processing and software engineering
  - Shrinkage sensor sizes and innovative manufacturing

- **2020**
  - Cloud and mobile communication technologies
  - Wearables
    - Ingestible & implantable sensors
    - Ambulance drones
    - “Trauma care in a rucksack”
    - Smart homes

- **2025**
  - Artificial intelligence and Nano-technology

- **2030**

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You go to healthcare → Healthcare comes to you → You carry healthcare → Healthcare is inside you

Source: “The Singularity is Near” by Ray Kurzweil, PwC analysis
NO FEAR
We need to change our mindsets
As a clinician, I’ve always believed we should use technology to complement our clinical practices, not replace them *(at least not yet)*

*Are we losing the healing ‘touch’ of medicine?*

Image from: Philips / www.usa.philips.com

Man vs Machine
Could a robot do your job? Aviva will retrain you
DEEP MEDICINE

HOW ARTIFICIAL INTELLIGENCE CAN MAKE HEALTHCARE HUMAN AGAIN

ERIC TOPOL
So, with the future already here, let us ask ourselves some questions
What is there to share about AI in healthcare in general and what applications have already been mainstreamed?
What actually is AI? Or rather, what is it not?
$AI \neq IA$
Intelligent Automation (IA) is the layering of automation and intelligent technologies. It has profound transformational benefits and organisational implications that require robust operational excellence and organisational change to be successful.
**John McCarthy, 1956:** Researchers came together at the Dartmouth Summer Research Project on Artificial Intelligence to clarify and develop concepts around, “thinking machines.” The term Artificial Intelligence was picked for its neutrality and to avoid emphasizing the track on thinking machines at the conference. It was defined as machine simulation that encompasses, “...every aspect of learning or any other feature of intelligence precisely described...”

English Oxford Living Dictionary: The theory and development of computer systems able to perform tasks normally requiring human intelligence, such as visual perception, speech recognition, decision-making, and translation between languages.

Merriam-Webster: (1) A branch of computer science dealing with the simulation of intelligent behavior in computers, (2) The capability of a machine to imitate intelligent human behavior.

Encyclopedia Britannica: The ability of a digital computer or computer-controlled robot to perform tasks commonly associated with intelligent beings, intelligent beings referring to those that are able to adapt to changing circumstances.

Amazon: The field of computer science dedicated to solving cognitive problems commonly associated with human intelligence, such as learning, problem solving, and pattern recognition.
Artificial Intelligence

Machine Learning

Deep Learning
The subset of machine learning composed of algorithms that permit software to train itself to perform tasks, like speech and image recognition, by exposing multilayered neural networks to vast amounts of data.

Artificial Intelligence

A subset of AI that includes abstruse statistical techniques that enable machines to improve at tasks with experience. The category includes deep learning.

Any technique that enables computers to mimic human intelligence, using logic, if-then rules, decision trees, and machine learning (including deep learning).

Source: https://medium.com/datadriveninvestor/ai-vs-machine-learning-vs-deep-learning-ba3b3c58c32
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PwC June 2019
Is there anything to say about AI in healthcare in general?
ARTIFICIAL INTELLIGENCE

AI could also have a tremendous impact in healthcare through solutions such as:

- Online Consultation
- Automating repetitive tasks
- Data mining of medical records
- Medication management
- Drug creation
- Designing treatment plans
What applications currently exist?
- Abnormal gene identification (e.g. antibiotic resistance, cancer therapy resistance)
- Pattern recognition from data (e.g. electronic medical records, x-rays)
- Secondary diagnostic support system (e.g. electronic medical records)
- Decision support system (e.g. electronic medical records)
- Predictive analytics (e.g. electronic medical records, remote monitoring)
- Brain-computer interfaces (e.g. stroke patients)
- Arrhythmia identification (e.g. implantable defibrillator)
- Medical awareness and education (e.g. online to offline in emerging markets)
- Image recognition systems (e.g. pathology, radiology, dermatology)
- Health and wellness (e.g. wearables)
- Patient monitoring and alert system (e.g. ward and ICU remote monitoring)
- Surgical assistance (e.g. identification of anatomic structures at risk)
- Virtual/Augmented/Mixed Reality
Are there any applications that have already been mainstreamed?
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If “following the money” is the quickest path to the root of a trend, then 2019 promises to be the year artificial intelligence takes center stage in the healthcare industry.

By 2024, AI in the U.S. healthcare market is set to exceed $10 billion according to a recent Global Market Insights report.\textsuperscript{[1]} As nearly eight out of ten healthcare executives who responded to a recent cross-industry survey said their organizations are ramping up investments in big data analytics and AI, it should come as no surprise that the market is truly ramping up.\textsuperscript{[2]} Nearly 80 healthcare AI startups raised their first equity rounds in 2017 and corporate healthcare funding for AI and predictive analytics reached nearly a half a billion dollars in 2017.\textsuperscript{[3,4]} AI was also the talk of the town at the recent J. P. Morgan Healthcare Conference, the largest healthcare investment symposium in the industry.
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AnalyticsMD, which is launching out of Y Combinator’s latest batch, is a startup tackling a difficult but very worthwhile problem: how to boost the operational efficiency of hospitals and improve patient care by helping staff make better choices about how resources are allocated. Its founders liken their product to an “air traffic controller for the hospital and healthcare system”.

Their real-time analytics platform predicts changes in demand so that resources such as extra staff and beds can be brought in before they are needed to prevent scenarios such as emergency room waiting times spiraling outside target limits or the quality of patient care suffering. The HIPAA compliant SaaS software has been rolled out to several paying customers in the U.S. healthcare sector so far, including a major San Francisco Bay Area hospital system.
Our technology takes a modular approach which means we cover a wide variety of disease areas to deliver better and more personalised care by transforming the way patients and data interact with clinicians. Our Artificial Intelligence division uses data collected through our platform to generate predictive insights which will be able to detect life threatening medical conditions.
1. Improve operational efficiency and performance

On a departmental and enterprise level, the ability of AI to sift through large amounts of data can help hospital administrators to optimize performance, drive productivity, and improve the use of existing resources, generating time and cost savings. For example, in a radiology department, AI could make a difference in the management of referrals, patient scheduling, and exam preparations. Improvements here can help to enhance patient experience and will allow a more effective and efficient use of the facilities at examination sites.

2. Aiding clinical decision support

AI-enabled solutions can help to combine large amounts of clinical data to generate a more holistic view of patients. This supports healthcare providers in their decision making, leading to better patient outcomes and improved population health. “The need for insights and for those insights to lead to clinical operations support is tremendous,” says Dr. Smythe. “Whether that is the accuracy of interventions or the effective use of manpower – these are things that physicians struggle with. That is the imperative.”

3. Enabling population health management

Combining clinical decision support systems with patient self-management, population health management can also benefit from AI. Using predictive analytics with patient populations, healthcare providers will be able to take preventative action, reduce health risk, and save unnecessary costs.

As the population ages, so does a desire to age in place when possible, and to maximize not only disease management, but quality of life as we do so. The possibility of aggregating, analyzing and activating health data from millions of consumers will enable hospitals to see how socio-economic, behavioral, genetic and clinical factors correlate and can offer more targeted, preventative healthcare outside the four walls of the hospital.

4. Empowering consumers, improving patient care

As recently as 2015 patients reported physically carrying x-rays, test results, and other critical health data from one healthcare provider’s office to another. The burden of multiple referrals, explaining symptoms to new physicians and finding out that their medical history has gaps in it were all too real. Patients now are demanding more personalized, sophisticated and convenient healthcare services.
Intermountain Healthcare and Trinity Health Make Growth Investment in AI Leader Jvion

Atlanta, Georgia, FEB 13, 2019 – Leading healthcare Artificial Intelligence (AI) firm Jvion announced a growth investment from healthcare leaders Intermountain Healthcare and Trinity Health. This round of funding is an expansion of the existing

Jvion delivers healthcare’s only secure, AI-driven prescriptive analytics platform. By using Eigen-based technology, the machine does what simple predictive analytics or machine learning models cannot. It goes beyond high-risk patient populations to identify those on a trajectory to becoming high risk. Jvion determines the interventions that will more effectively reduce risk and enable clinical action. And it accelerates time to value by leveraging established patient-level intelligence to drive action across hospitals, populations, and patients. For more information, visit www.jvion.com.
Zebra Medical Vision gets $30M Series C to create AI-based tools for radiologists

Zebra’s mission is to provide radiologists the tools they need to make the next leap in patient care. The demand for medical imaging services is continuously increasing, outpacing the supply of qualified radiologists and stretching them to produce more output, without compromising patient care. Only by adopting new technology that significantly enhances the capabilities of radiologists, can this crisis be mitigated. Zebra is empowering radiologists with its revolutionary AI offering which helps health providers manage the ever increasing workload without compromising quality.
Adding artificial intelligence to speech recognition for more efficient EHR documentation

BY TINA JOROS · MAY 23, 2018

Samantha™, The EHR Virtual Assistant from NoteSwift, Inc. does exactly that.

With Samantha, Allscripts Professional EHR™ users can enter the entire patient note from a single screen – either by typing or using any speech recognition dictation product. Once the narrative is entered, Samantha’s artificial intelligence goes to work as she:

• Intelligently parses the narrative and identifies the structured data elements
• Ensures the terms dictated are entered in the terminology the EHR expects
• Assigns required ICD-10, SNOMED, CPT, and other codes automatically
• Provides a means for the user to confirm or correct any ambiguous information, and
• Transparently inputs data, codes and check marks in the correct sections of the EHR
MD Anderson Diagnostic support

IBM Watson Imaging Clinical Review
Watson Health Imaging Clinical Review is a retrospective AI-enabled data review tool that helps support a reliable patient record in order to drive accurate, timely, and coordinated care decisions.

IBM Watson Imaging Patient Synopsis
Patient Synopsis is a radiologist-trained AI tool that helps to efficiently inform clinical care decisions by extracting patient information from the EHR and projecting it via a single-view summary in sync with PACS.

Watson Health Enterprise Imaging Solutions
Discover our enterprise imaging solutions for radiology, cardiology, orthopedics and eye care, and applications that fuel the largest modality vendors in the world.
Automated diabetic retinopathy detection in smartphone-based fundus photography using artificial intelligence

Ramachandran Rajalakshmi, Radhakrishnan Subashini, Ranjit Mohan Anjana & Viswanathan Mohan
How an academic medical center integrated AI into its Epic EHR to improve diagnoses

By Bill Siwicki | July 25, 2018 | 09:26 AM

The department of emergency medicine at the University of Maryland uses imaging-oriented technology as a virtual specialist in the ER.

VisualDx works by using artificial intelligence to compare hundreds of thousands of medical images against the symptoms entered by physicians into the platform. The tool then provides a physician with a few different possibilities for what the disease may be, and it enables users to add in additional symptoms and patient demographics to deliver a more accurate diagnosis, Browne said.

Additionally, the University of Maryland has VisualDx integrated into its Epic EHR such that clinicians can use it via the electronic health record, or on desktop or mobile devices.
5 Amazing Things Google’s DeepMind AI Can Already Do

By Megan Ellis / October 29, 2018 / 6 minutes

1. DeepMind AI Taught Itself to Walk
2. DeepMind’s AI Can Create Its Own Images
3. DeepMind Bots Can Strategically Out-Think Humans
4. DeepMind AI Taught Itself How to Navigate Without a Map
5. DeepMind Can Detect Certain Diseases Better Than Doctors
Ask Babylon → Talk to a doctor → Healthcheck

Hi Alex, how can I help?

I've got a really bad headache and I don't know what to do...

No problem, let me ask you a few questions...
ENLITIC STUDY SHOWS RADIOLOGISTS 21% FASTER WORKING WITH AI
Remember however, how many of the categories of application and examples provided are truly AI solutions is questionable!!
We understand that AI has been used in imaging, and data seems to suggest that AI may be able to detect some conditions better than humans. Is this True/False/Skewed?
True but Skewed
Jeremy Hunt's rash advice to Google kids' spots - cartoon
The health secretary's suggestion that parents go online to check symptoms is 'potentially fatal', according to doctors
Ian Williams
Wed 3 Feb 2016 18:38 GMT

This AI Just Beat Human Doctors On A Clinical Exam
Parmy Olson
Forbes Staff
AI, robotics and the digital transformation of European business.

The average passmark for the MRCGP exam, which trainee general practitioners take to test their ability to diagnose, has been 72% over the past five years.

“How did Babylon Health do?” he asked, before waiting a beat. “It got 82%.” Several people clapped loudly, sparking applause from the rest of the audience. The AI had beat human doctors handily.

But for now, the artificial doctor’s brain built by Babylon, which has raised $85 million since its founding five years ago, works when it’s put in a test environment. And while regulations limit it to providing medical advice only, it may be only a matter of time before it’s trusted to make a diagnosis and even write a prescription.
What are some examples of AI in the imaging and diagnostic spaces?
New Health Economy
Partnerships are important...
Is there anything worth mentioning on Regulations & Legal Issues? If so, are there Regulations & Laws in Singapore (or elsewhere) that are related to AI in healthcare in particular that may be interesting to a Malaysian audience?
Before we discuss regulations and legal issues, what are some of the risks associated with AI in healthcare?

- Algorithm bias (data itself and/or coder)
- Wrong decision(s) and/or recommendation(s) because all scenarios not accounted for
- Unethical outcomes (compassion and empathy are lacking)

- Data privacy, security and governance (malfunctioning of system, attack by hackers)
Are there any regulations or laws related to AI in healthcare in particular locally, regionally and/or globally?
Does anything exist then?

Explanations...Frameworks...Guidelines...
Though efforts to regulate AI in healthcare have been slow to develop, the U.S. government has already integrated AI into different areas of its own oversight of the healthcare industry. For example, *Recovery Audit Contractor* (RAC) teams working on behalf of the Centers for Medicare and Medicaid Services (CMS) are utilizing algorithms powered by AI to identify billing irregularities in diagnosis-related groups (DRG), a coding system that denotes a particular diagnosis for a hospital inpatient stay for purposes of payment.\(^\text{16}\) The delay in regulation for AI may generally be attributed to the following: (1) the federal government has not promulgated a clear definition of AI, and without it, the construction of an effective regulatory system is unlikely; (2) the autonomy of AI poses significant liability concerns; and, (3) federal and state governments may struggle to design a regulatory framework around a technology that will likely continue to rapidly evolve, in both design and utilization.\(^\text{27}\) AI is advancing on a daily basis, and government lawmakers and regulators will necessarily have to respond with innovative laws to regulate this technology, especially as it relates to healthcare.
The first edition of this accountability-based Model Framework aims to frame the discussions around the challenges and possible solutions to harnessing AI in a responsible way. The Model Framework aims to collect a set of principles, organise them around key unifying themes, and compile them into an easily understandable and applicable structure. It seeks to equip its user with the tools to anticipate and eventually overcome these potential challenges in a practical way.
1.1 The Model AI Governance Framework ("Model Framework") focuses primarily on four broad areas: internal governance, decision-making models, operations management and customer relationship management. While the Model Framework is certainly not limited in ambition, it is ultimately limited by form, purpose and practical considerations of scope. With that in mind, several caveats bear mentioning: the Model Framework is

a. Algorithm-agnostic. It does not focus on specific AI or data analytics methodology. It applies to the design, application and use of AI in general;

b. Technology-agnostic. It does not focus on specific systems, software or technology, and will apply regardless of development language and data storage method; and

c. Sector-agnostic. It serves as a baseline set of considerations and measures for organisations operating in any sector to adopt. Specific sectors or organisations may choose to include additional considerations and measures or adapt this baseline set to meet their needs.
1.2 It is recognised that there are a number of issues that are closely interrelated to the ethical use and deployment of AI. This Model Framework does not focus on these specific issues, which are often sufficient in scope to warrant separate study and treatment. Examples of these issues include:

a. Articulating a set of ethical principles for AI. There are a number of attempts globally in establishing a set of principles. While there is a consistent core set of ethical principles, there is also a penumbra of variation across cultures, jurisdictions and industry sectors. The Model Framework does not set out to propose another set of such principles although it compiles a glossary from existing literature.

b. Providing Model Frameworks and addressing issues around data sharing, whether between the public and private sectors or between organisations or within consortia. There are a number of guides that are relevant, i.e. the PDPC Guide to Data Sharing and the Guide to Data Valuation for Data Sharing.

c. Discussing issues relating to the legal liabilities associated with AI, intellectual property rights and societal impacts of AI, e.g. on employment, competition, unequal access to AI products and services by different segments of society, AI technologies falling into hands of wrong people, etc. These issues are nevertheless pertinent and will be explored separately through the Centre for AI and Data Governance established in the Singapore Management University School of Law or other relevant forums.
“...also don’t have concerns...”
AI Singapore

To anchor deep national capabilities in Artificial Intelligence, thereby creating social and economic impacts, grow local talent, build an AI ecosystem and put Singapore on the world map.

Three Key Pillars

AI Research

Invest in deep capabilities to catch the next wave of scientific innovations and breakthroughs.

AI Technology

Address major challenges that affect our economy and society thereby promoting bold ideas and the application of innovative AI technologies.

AI Innovation

Broaden the use and adoption of AI in Singapore and groom local AI talents to support industry growth.
“Trustworthy AI has three components.”

“...lawful...ethical...robust...”

- Health and well-being

Trustworthy AI technologies can be used – and are already being used – to render treatment smarter and more targeted, and to help preventing life-threatening diseases. Doctors and medical professionals can potentially perform a more accurate and detailed analysis of a patient’s complex health data, even before people get sick, and provide tailored preventive treatment. In the context of Europe’s ageing population, AI technologies and robotics can be valuable tools to assist caregivers, support elderly care, and monitor patients’ conditions on a real time basis, thus saving lives.

Trustworthy AI can also assist on a broader scale. For example, it can examine and identify general trends in the healthcare and treatment sector, leading to earlier detection of diseases, more efficient development of medicines, more targeted treatments and ultimately more lives saved.
Conclusion
Augmented and Virtual Reality in Healthcare

ASEAN Healthcare Transformation Summit

19 March 2019

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Augmented and Virtual Reality in Healthcare

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As a clinician, I’ve always believed we should use technology to complement our clinical practices, not replace them *(at least not yet)*

Are we losing the healing ‘touch’ of medicine?
1920s

Image from: NY Times

2016

Image from: University of Illinois at Chicago
“In my humble opinion, the aim of education should be to teach us how to think rather than what to think.”

- Prof. Jimmy S Daruwalla
PATIENTS
Informed decision making and support

Safe, quality care

Compassion
Empathy

The human touch

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Image from: https://livingfullywellness.files.wordpress.com/2015/10/slide1.jpg
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People
Privacy

Technology
Transformation

Engagement
Experience
Expertise

Transparency
Treatment

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THANK YOU

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