AI in
health care

Foreword

Technology as we know it is changing before our eyes, and is poised to transform the world around us. Artificial intelligence (AI) is the catalyst behind the latest wave of technological and industrial advancements, accelerating the pace of change across all industries from agriculture to manufacturing.

Health care, in particular, is ripe for AI innovation and this will impact not only our daily lives but also economic development. China and many countries currently face similar challenges in health care, including inadequate access and unbalanced distribution of high-quality medical resources and services. This is where AI can help.

AI can be used to address global health-care challenges and provide better and more comprehensive health-care services to the general public.

Potential applications of AI technology in health care continue to increase and its impact is far-reaching, from medical imaging analysis to assisted clinical decision-making; from hospital treatment workflow management to health management outside hospitals; and from empowering doctors to empowering pharmaceutical companies. AI developments make high-quality medical resources more accessible, increase resource-sharing, and improve the efficiency of diagnosis and treatments.

AI will bring better medical care, but with that will come its own set of challenges in areas of data, technology, security, regulations, ethics, and talent. These efforts will require attention across the board to ensure that digital transformation is handled securely and responsibly. As we scale up the applications of AI in the medical field, we will be required on one hand to uncover and solve expected and unexpected problems that arise, and on the other hand constantly create and improve relevant laws and regulations to ensure the healthy development of the new AI-powered medical model.

We firmly believe that applying AI technology to medical care will transform the industry and improve everyone's lives.

Haifeng Wang
Chief Technology Officer
Baidu

Preface

"AI in health care: Capacity, capability, and a future of active health in Asia" is an MIT Technology Review Insights report sponsored by Baidu. The report was produced through interviews with health care and technology leaders from around the region, desk research, and field visits to medical facilities in China to evaluate how AI is being used to improve health service outcomes. Specifically, it is looking at the ways that the region's health care delivery providers, technology companies, and government agencies collaborate to identify and tackle large and chronic health-care challenges in their respective countries.

MIT Technology Review Insights assessed various areas in which Asian AI ecosystem participants are innovating solutions; these include tools and platforms for medical image diagnosis and analysis, treatment decision support software for physicians, predictive analytics for identifying risk, and the use of natural language processing to provide health services to the elderly. Claire Beatty was the editor of this report and Nicola Crepaldi was the publisher. The research is editorially independent and the views expressed are those of MIT Technology Review Insights.

We would like to thank the following experts for contributing their time and insights to this research program:

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01 Executive summary

Software and platforms powered by AI are expected to transform Asia's health-care landscape in the decade ahead, allowing health providers and government health-care authorities to increase capacity of service delivery, speed of diagnoses, quality of care, and overall patient health outcomes. The use of AI cannot be described as entirely nascent; indeed, it is already being widely used—particularly in developed Asia. Yet new use cases, new innovations, and new centers of AI adoption are emerging constantly, and the continuing urgency by governments and tech players to diffuse AI across health-care ecosystems will bring untold benefits to patients' lives across the region. The key findings of "AI in health care: Capacity, capability, and a future of active health in Asia" are as follows:

AI is efficiently narrowing Asia's health-care gap.
AI is an important and pragmatic solution for increasing the capacity and efficiency of health-care provision across the region. Health care resources in many countries are strained, chiefly due to a dearth of human capital—the World Health Organization (WHO) estimates that Asia will require over 12 million new professionals by 2030, an increase of over 70% from current levels. Spending is another challenge. Outside of developed Asian economies, health expenditure per capita is less than a quarter of OECD levels. Against this backdrop there is a growing set of success cases in using AI to boost the productivity and accuracy of medical staff.

The region is benefitting from the increased capacity of front-line health-care staff.
This includes guiding doctors through diagnostic processes to arrive at treatment decisions with greater

New use cases, new innovations, and new centers of AI adoption are emerging constantly, and the continuing urgency by governments and tech companies to diffuse AI across health-care ecosystems will bring untold benefits to patients' lives across the region.

speed and certainty; using machine learning to analyze increasingly sophisticated medical images to diagnose a wide range of common and rare diseases, often with greater accuracy than humans; and wearable health-tracking technology to support patients in maintaining wellness, and doctors in spotting risks and warning signs.

Machine-human interaction is growing specialist skills across the region.
AI will drive Asia's health-care practitioners, particularly in advanced economies, towards a higher set of skills and

greater ability to work alongside technology. These include robot-assisted surgeries, highly accurate diagnoses of detailed medical images, and new drug development. However, since much of the region's health-care system is chronically overstretched and limited in its ability to provide the basics, some observers advocate focusing AI resources on first empowering primary health care.

Asia's highest health burdens are fertile ground for public-private sector collaboration.
In several Asian countries there are examples of different
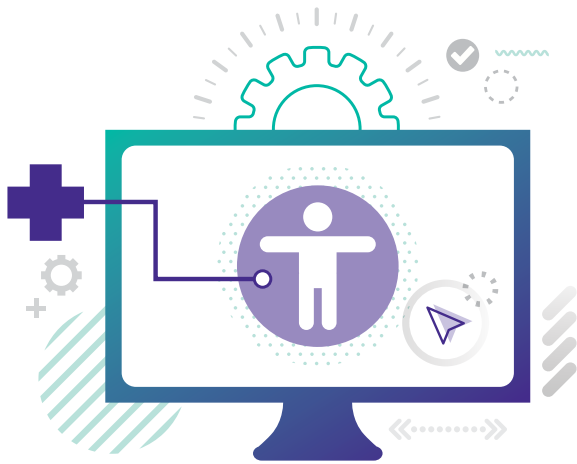
In the future, health-care ecosystems will emphasize wellness and well-being over curative care. AI will play a leading role in promoting "active health."

stakeholders collaborating to tackle a pernicious medical challenge while leveraging local skills and talent, or data resources. Aging is rapidly becoming one of Asia's leading health-care crises; Japan is currently in the lead for its share of the population aged over 65 (nearly a third), but several of the region's other economies are close behind and carefully watching the emerging innovations in elder care. Other health care burdens where AI is playing a leading role are infant mortality in India and hyperglycemia, hyperlipidemia, and hypertension (the "Three Highs") in Singapore. Over the coming decades, policymakers and AI developers will increasingly collaborate to improve public health.

Preventive strategies will come to the forefront of health care.
In the future, health-care ecosystems will emphasize wellness and well-being over curative care. AI will take a leading role in promoting "active health," as this trend is being called, by identifying disease markers and generating intelligence on susceptibility to any number of health conditions. The data will allow individuals to take control of their lifestyles and medical treatment, and proactively improve their health. Wearables and AI technology are converging to create new capabilities and deeper insights.

Health-care systems must remain human-centric.
The increasing contribution of technology to medical decision-making is undoubtedly a benefit to countless patients across Asia, yet it is ethically imperative that technology maintain a supporting role to the expertise of human doctors and practitioners. Final decision-making responsibility must continue to lie with humans, to guarantee accountability in the health-care system. AI developers should focus on making sure that AI is explainable and understandable both by doctors and patients, so that recipients and users of AI can continue to trust it and welcome it into their care.

02 The health-care gap

Asia's shortage of clinicians is compounded by insufficient health-care insurance coverage and the high cost of treating chronic conditions.
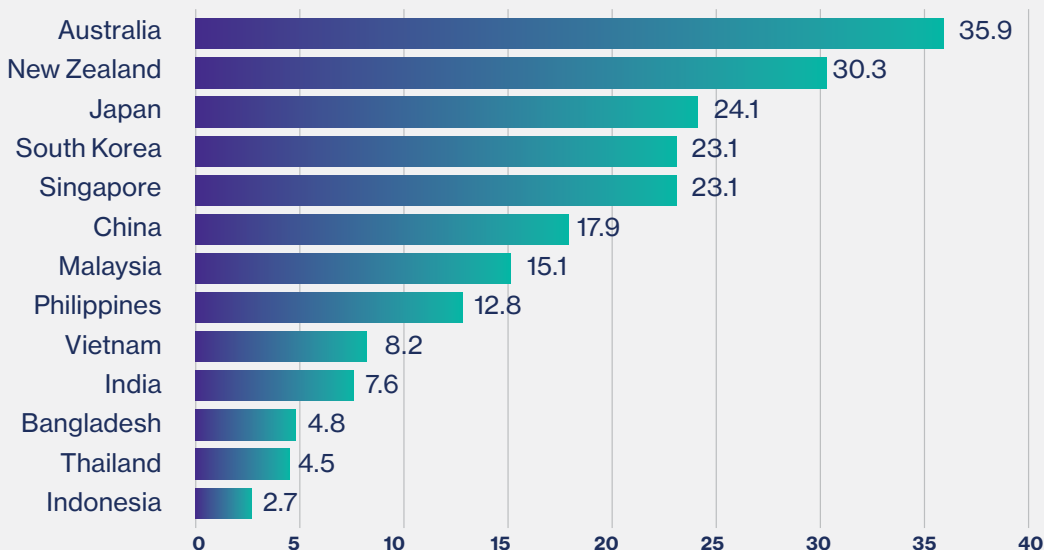
Asia is actively pursuing AI-enabled tools to bridge chronic gaps in health-care resources and meet growing new challenges, such as the pressure created by rapidly aging societies. The role of AI in accelerating innovation and redefining value for health-care providers and organizations is expected to be truly transformative, but the reality today is that AI's true utility in health contexts is in augmenting existing processes and providing more insight and intelligence to the region's sorely-tested medical professionals.

Asian health-care statistics generally paint a bleak picture of coverage and resource ability, even in advanced economies.
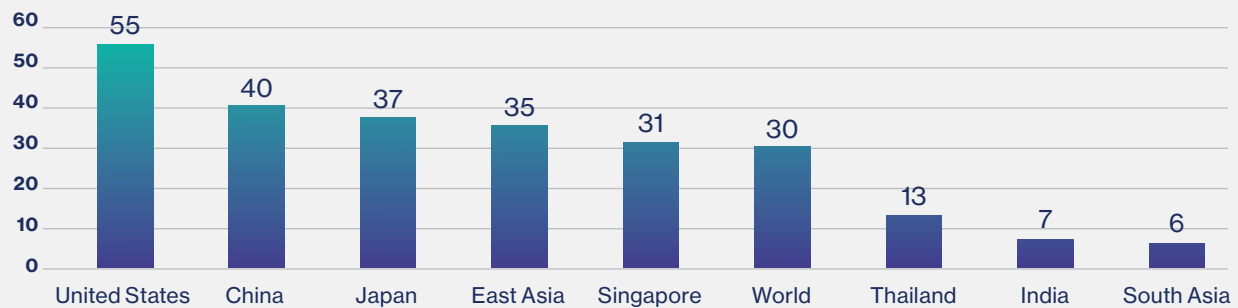
Chief among the challenges is a dearth of human capital: Even in wealthy Japan, Korea, and Singapore, the number of medical doctors per 10,000 people is below 25, the lowest density in the developed world. In south and southeast Asia—home to over 2.25 billion people, over half of Asia's total—the number of doctors per 10,000 averages fewer than seven (see Figure 1).

Specialized medical professionals can also be scarce in parts of Asia, in south Asia in particular. And although the density of specialists in east Asia is above the global average, they stand well behind the resources of developed markets like the US—and gaining access to these resources for the majority of Asian patients can be difficult and costly.

Figure 1: Medical doctors per 10,000 population, 2016 or latest available

Country	Value
Australia	35.9
New Zealand	30.3
Japan	24.1
South Korea	23.1
Singapore	23.1
China	17.9
Malaysia	15.1
Philippines	12.8
Vietnam	8.2
India	7.6
Bangladesh	4.8
Thailand	4.5
Indonesia	2.7

Source: World Health Organization

Figure 2: Medical specialists per 100,000 population, 2014

United States	55
China	40
Japan	37
East Asia	35
Singapore	31
World	30
Thailand	13
India	7
South Asia	6

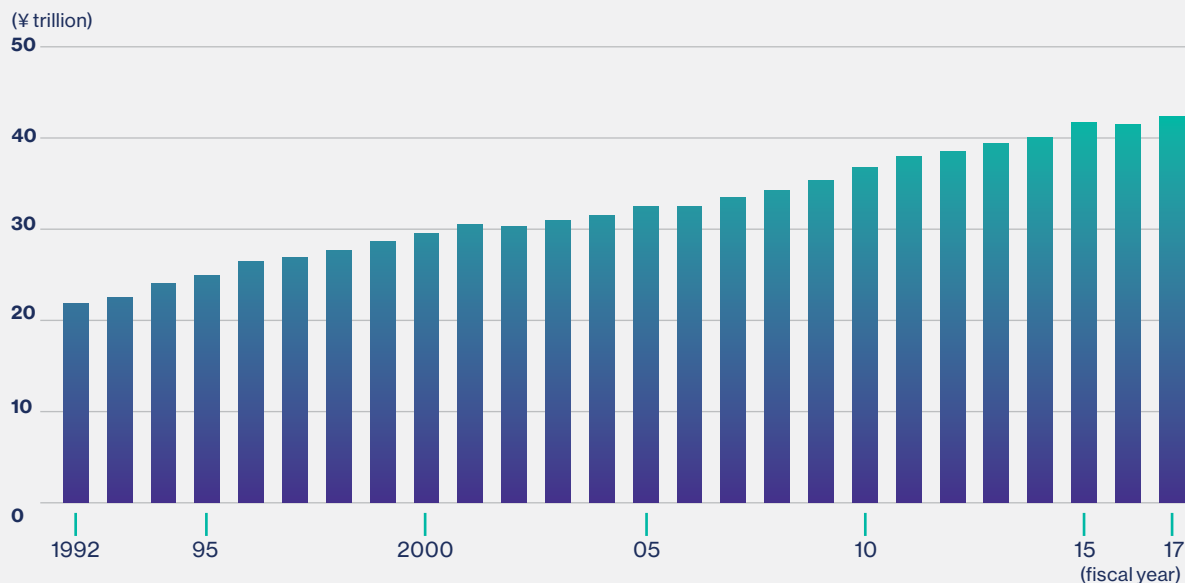Source: The Lancet Commission on Global Surgery, 2014

Given the pressures Asia's citizens and service providers face, and the region's increasingly strong focus on developing AI resources, there is a growing set of success stories in the use of AI to accelerate positive health-care outcomes.

This human resource deficit is compounded by the lack of effective health-care protection coverage and the high cost of chronic disease treatment. Insurer Swiss Re estimates that these affordability drivers contribute to a $1.8 trillion health-care gap for some 40 million households in 12 countries across Asia—nearly half of which are in China alone—which results in tremendous stress on household finances and well-being.[1] This hardship has restricted access to health services for much of Asia; the OECD estimates that in the lowest income quintiles, more than half of women in a variety of south and southeast Asian countries report an inability to access health care for financial reasons.[2]

Governments across the region are challenged in their ability to fund adequate health-care services. Outside of developed Asian economies, health expenditure per capita is less than a quarter of OECD levels (see Figure 3).

Figure 3: Health-care expenditure per capita, 2015

- Government/compulsory
- Voluntary/out-of-pocket

Australia	4,491
Japan	4,405
Singapore	3,681
New Zealand	3,530
South Korea	2,556
Malaysia	1,063
China	762
Thailand	610
Indonesia	369
Sri Lanka	353
Viet Nam	334
Philippines	322
Myanmar	267
India	237
Cambodia	209
Pakistan	134
Bangladesh	88

OECD, 3,800 USD PPP

USD PPP
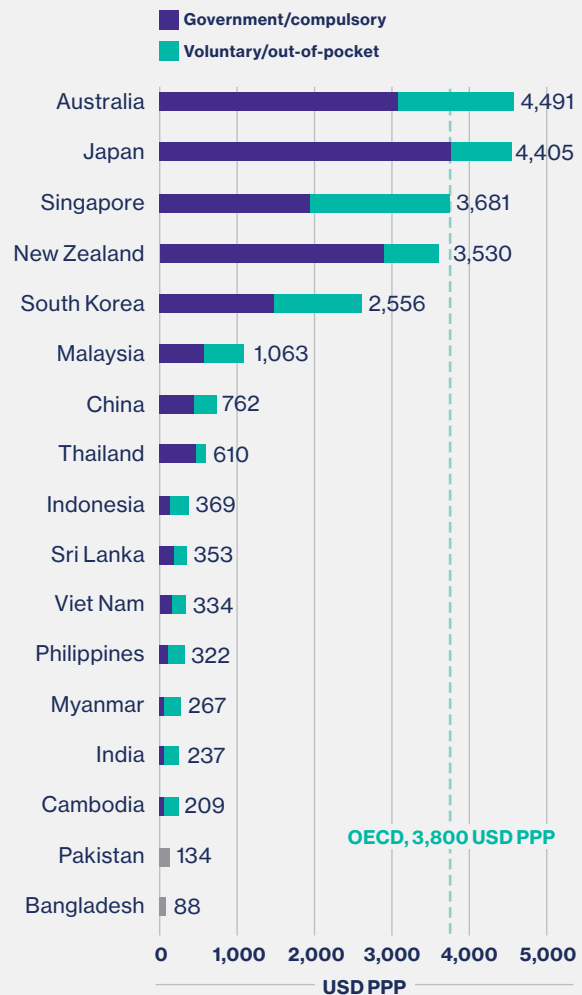
Source: WHO Global Health Expenditure Database (2018f); OECD Health Statistics (2018)

Figure 4: Estimated health-care expenditure, Japan, 1992-2017

(¥ trillion)

Source: Nippon.com based on the Ministry of Health, Labor, and Welfare's 2017 Healthcare Expenditure Trends report

In wealthier Asian countries, the challenges of aging populations and growing debt levels cause additional financial strain; Japan's government spent ¥42.2 trillion (US$ 396 billion) on health care in 2017, 30% more than it had a decade ago, according to the Ministry of Health Labor and Welfare (see Figure 4).

Unsurprisingly, given the pressures Asia's citizens and service providers face, and the region's increasingly strong focus on developing AI resources, there is a growing set of success stories in the use of AI to accelerate positive health-care outcomes. Virtual assistants employing decision-support for consumers and customer experience professionals is a common emerging AI use case across many industries in Asia and the world. They operate on the assumption that increased insight into a transaction can speed up sluggish processes and disintermediate unneeded ones. But health-care systems in Asia, while often burdened with bureaucracy, largely present a different set of challenges.

Emerging AI use cases in health

The most efficacious applications are not being built to run health care operations more smoothly, but to boost the top-line productivity and provide better, more powerful insight into diagnosis and treatment plans. Applications for AI and other emerging technologies are typically clustering around the following use cases:

Decision support for health-care professionals.
AI-enabled analysis software is helping to guide doctors and other health-care workers through diagnostic processes and questioning to arrive at treatment decisions with greater speed and accuracy. In Beijing, China, Baidu has launched its Clinical Decision Support System (CDSS) in nearly 1,000 hospitals, which supports doctors by guiding them through standard diagnosis procedures and recommending treatment plan options.

Medical image analysis and diagnosis support.
A fast-growing segment of AI innovation globally—machine learning is being used to analyze increasingly sophisticated magnetic resonance imaging (MRI), computed tomography (CT) scans, and other medical images to diagnose fractures, cancers, strokes, and many other conditions. Yitu Technology, a venture capital-financed AI startup, has leveraged the country's leadership in facial recognition R&D along with the West China Hospital Chengdu's lung cancer database to build a 4D CT scan analysis system for lung cancer diagnosis.

Virtual assistance for patients. There is an emerging set of AI-supported tools to assist patients in navigating through choices and optimizing selections, such as for informal self-diagnosis, finding doctors, and booking appointments. These tools have currently gathered more traction in the US and Europe, where there is often a need to optimize choice amongst a long list of options, yet they are also beginning to find application in Asia. In China, insurance company Ping An's Good Doctor has a variety of online consultation and triage functions and has an estimated 180 million registered users.

Administrative workflow assistance. Emerging technology platforms, such as those developed by US AI giant Inovalon, are using natural language processing (NLP) and deep learning algorithms to analyze and codify medical records and procedures faster, and to conduct automatic reviews of documentation and patient history to improve ongoing care and support.

Robot surgeons. Cognitive robotic technology is being used to enhance the analysis of patients' pre-surgery medical data and make decisions about specific surgical strategies and methods, often culminating in physically assisting the surgeon in executing the procedure. Consulting firm Accenture estimates that robot-assisted surgery can create over $40 billion in savings for the US health-care system.[3] In Asia, a Japanese startup, Riverfield Surgical Robot, is building a platform called EMARO, which combines physical guidance and support with enhanced analysis of medical image data from pre-operation records.

Fraud mitigation. AI software can use NLP to analyze insurance claims data—much of which is unstructured and non-standard—to identify patterns and suspects of fraudulent or inaccurate claims. This is more of an issue in markets with complex, costly, and non-nationalized health-care regimes—in the US, the Federal Bureau of Investigation estimates the range of annual insurance fraud and abuse to be between $90 billion and $300 billion—but there are also Asian applications emerging. Large Asian insurers, such as Sompo in Japan, are using AI in claim adjustment and fraud detection processes.

The proliferation of smart watches, fitness monitors, and, of course, smartphones in Asia has given rise to numerous applications for monitoring health data such cardiovascular activity, pulse rate, and sugar and oxygen levels. Coupled with AI analytics, this data can be used to assess health risks and spot warning signs, as well as design preventative or health-enhancing practices. This will increasingly involve incorporating DNA analysis, where AI can enhance the quality of the DNA analysis itself, consider meta-data about patient history, and track records of DNA testing suppliers to help patients and health-care professionals select the best provider. In Asia, specialized devices to assist patients and their caregivers in achieving health outcomes or manage care routines are beginning to emerge; witness the rise of Japanese startup Triple W's DFree toilet timing monitor, that helps caregivers look after the elderly.
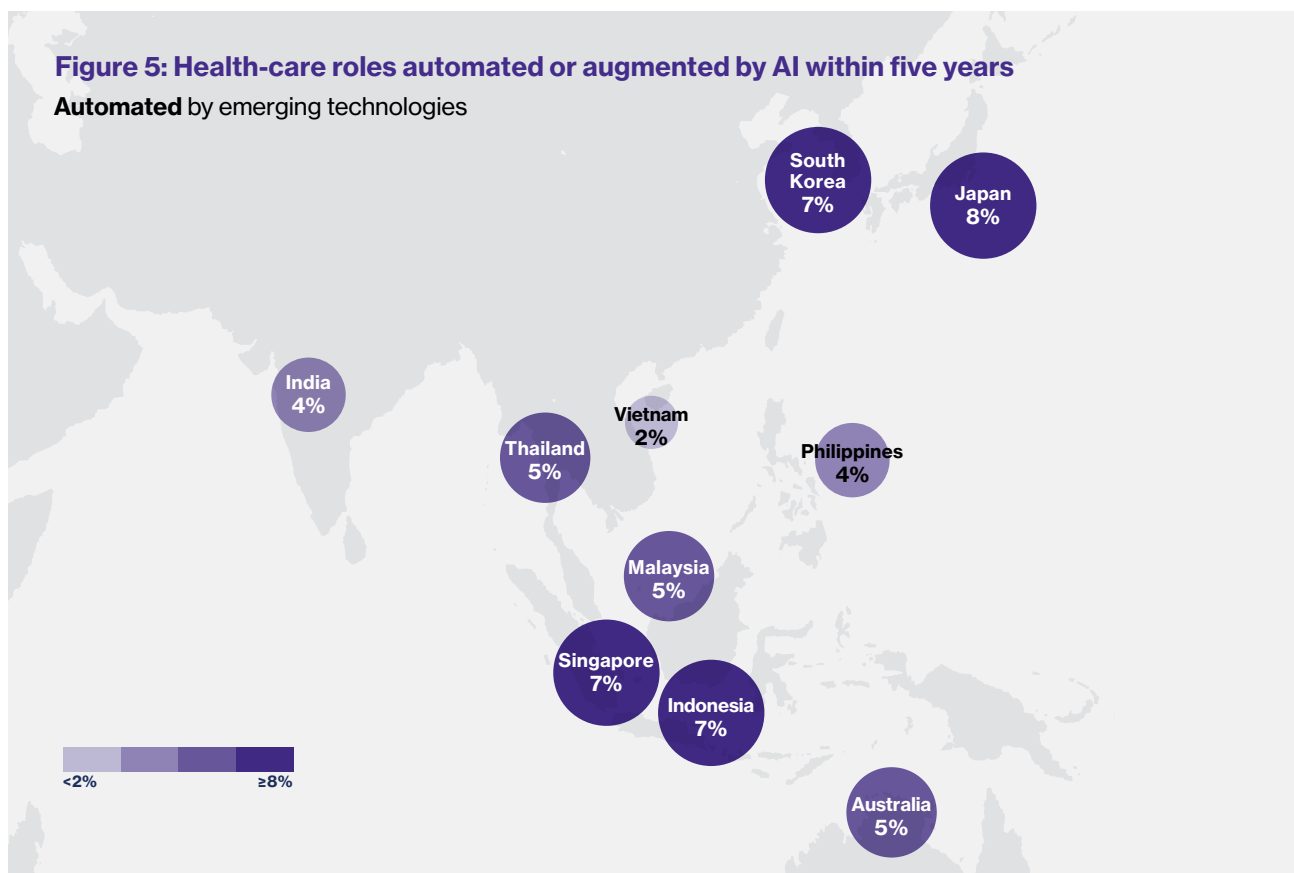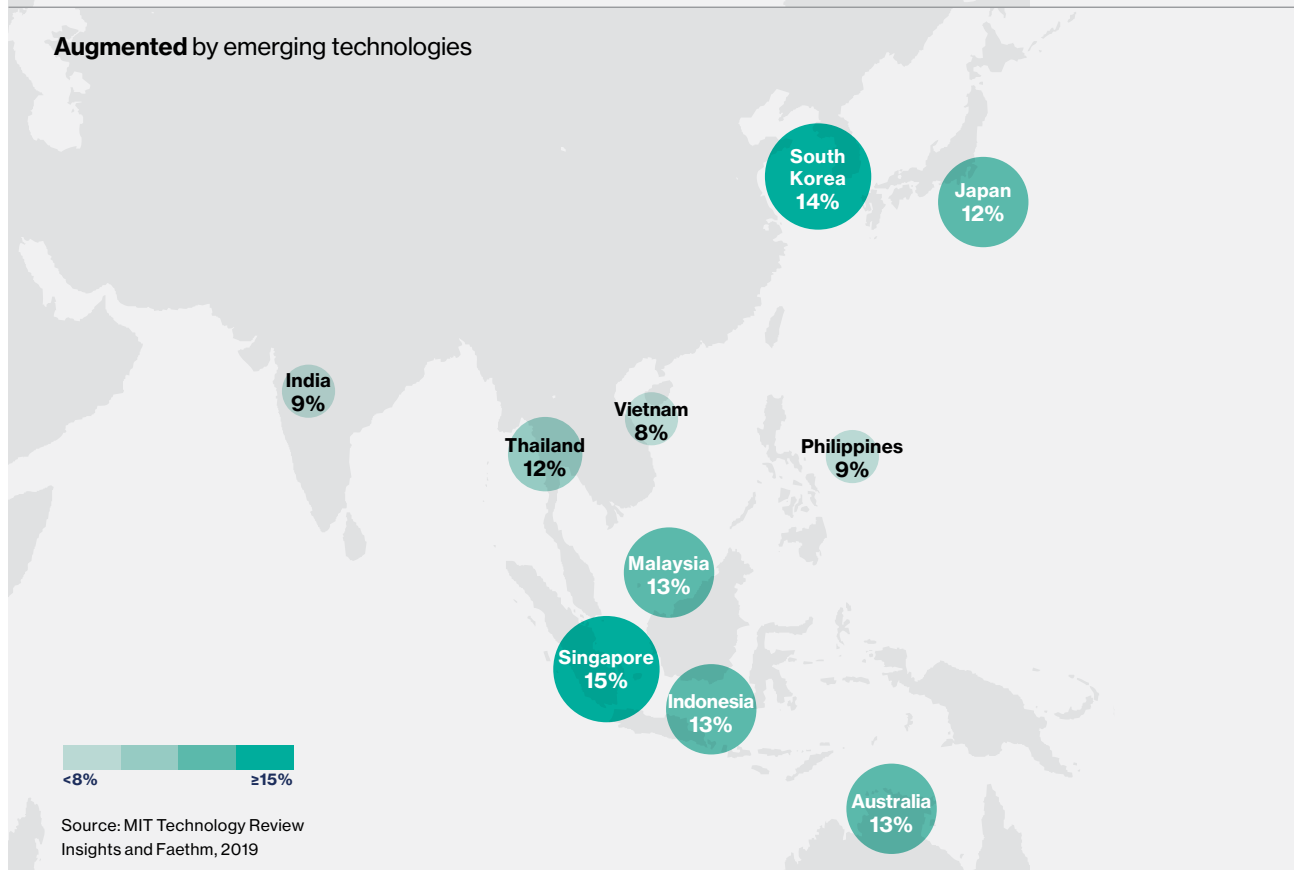
03

Extending health-care talent and skills

From Japan to India, AI is already having an impact in extending the reach of health-care services and amplifying the efforts of health professionals all across Asia. Boosting the speed and accuracy of disease detection, or providing insight and decision support to clinicians, are emerging as the primary aims for mitigating the region's persistent and growing lack of capacity in medical personnel and resources. The World Health Organization estimates that Asia will require over 12 million new professionals by 2030, an increase of more than 70% from current levels. While bridging Asia's medical talent shortfall may be driving the current wave of AI adoption, policymakers and AI entrepreneurs are also thinking about the technology in more transformative ways, and working to develop AI applications that will allow the region's health-care systems to function in more proactive, preventative ways.

Like most industries that are witnessing the rapid deployment of emerging technologies, there has been much discussion about the potential of AI to eliminate existing or future health-care jobs. In "AI and human capital," MIT Technology Review Insights estimated that across 11 Asia-Pacific markets, health care will be one of the sectors that will benefit from AI and automation. While there will be job losses in the sector, from about 8% in Japan to about 5% in the Philippines, a bigger impact is that jobs will be augmented and enhanced with emerging technologies. The research showed that in markets like Singapore and South Korea, some 14% of health-care jobs will become more efficient and productive due to AI.

Automation will drive the industry's practitioners, particularly in advanced economies, toward a higher set of skills, with greater ability to work alongside technology. However, the reality is that Asia's medical ecosystem still relies on far too few trained practitioners to begin with, and as the region's health-care needs continue to grow. AI is an important and pragmatic solution to increase the efficiency and value of the health-care sector.

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Figure 5: Health-care roles automated or augmented by AI within five years

Automated by emerging technologies

South Korea 7%

Japan 8%

India 4%

Vietnam 2%

Thailand 5%

Philippines 4%

Malaysia 5%

Singapore 7%

Indonesia 7%

Australia 5%

<2%   ≥8%

Augmented by emerging technologies

South Korea 14%

Japan 12%

India 9%

Vietnam 8%

Thailand 12%

Philippines 9%

Malaysia 13%

Singapore 15%

Indonesia 13%

Australia 13%

<8%   ≥15%

Source: MIT Technology Review
Insights and Faethm, 2019

Baidu's Clinical Decisions Support System (CDSS) has increased the capability of Pinggu's doctors, who used to serve fewer patients, and work with fewer diseases. More and more patients are now going to the clinics instead of higher-level hospitals, as the perception of service levels has significantly improved.

Empowering health-care providers

Huang Yan, general manager of Baidu Intelligent Healthcare—an AI health-specialized division established in 2018—explains that the Chinese internet search giant is seeking to harness its core technology assets, "to use evidence-based AI to empower primary health care." The group's technology development strategy was developed in collaboration with the Chinese government and industry thought leaders. "A core issue in the Chinese health-care system is the systemic imbalance of medical resources," says Huang. "China has a huge population and an increasingly ageing society, which increases demand for quality medical services, but the number of capable doctors is just not enough and most of them are in large cities."

Monetization of AI in health care is not a priority for Baidu at the moment, Huang observes. "Medical services are value-oriented, so commercial opportunities will arise if we can bring significant value to the health-care system. We've received very positive feedback from patients and grassroots hospitals since our products launched."

Capacity and confidence in China's Tier 1 facilities

Baidu is building capacity in China's public health-care facilities at a grassroots level through the development of its Clinical Decision Support System (CDSS), an AI software tool for recommending diagnosis and treatment plans for primary health-care providers. This tool is being designed to assist staff in what are known as Tier 1 facilities. China's public hospitals are stratified into three tiers: Tier 3 hospitals are usually large comprehensive facilities, with more than 500 beds, while Tier 1 facilities are designed to be smaller facilities in less prosperous urban or rural areas, most with fewer than 100 beds, and only a handful of staff, most of whom are not fully-trained or licensed doctors or nurses.

Tier 1 facilities were designed to serve as initial access points for basic health services. However, due to the widespread perception that the services provided by Tier 1 facilities are undertrained and underfunded, most patients in China strongly prefer going to Tier 3 hospitals

for their scale and access to specialist treatment. The result, Huang observes, has been to harden "a systematic imbalance in China's health-care capabilities," with increasingly empty Tier 1 clinics failing to act as the primary care providers that they were designed to be, as the resources of Tier 3 hospitals undergo greater strain.

In light of the issue, Baidu's intention, explains Huang, "is to increase people's access to quality medical services through improving the capability of Tier 1 hospital doctors." The efforts are in line with the Chinese government's initiative of tiered diagnosis and treatment in recent years, which encourages development of Tier 1 hospitals with the aim of enabling nearby residents to get medical services instead of turning to large hospitals.

A Tier 1 facility in Pinggu, a suburb of 460,000 people in northeast Beijing, is a typical site for deploying Baidu's CDSS. Through the CDSS, explains **Jiao Junfeng**, director of <u>Pinggu District's Public Health Bureau Information Center</u>, local facilities are able to effectively address demands of the entire administrative area, which consists of people living in 18 towns and 140 villages. Baidu's strategy aligns with the national policy of concentrating the detection and initial treatment of 66 diseases in Tier 1 community clinics, which often goes above the skills and capacity of the medical staff. "Local doctors usually do not have the skill set to deal with all of them," says Jiao, "and there is a lack of personnel to accommodate an increased demand. The goal of CDSS is to improve Tier 1 capacity," while policymakers also work to redirect traffic towards these clinics.

Jiao has been impressed with initial CDSS results in Pinggu. "Symptom recognition accuracy has been much higher than our expectations," he says. Doctors review an initial CDSS diagnosis, which usually identifies five highly possible diseases, along with recommended tests, treatments, and medicines. Another benefit, says Jiao, is that the presence of CDSS is adding to the credibility of Tier 1 service and quality. "It underscores and validates doctors' expertise in judgment, and has been strongly valued. It has increased the capability of Pinggu's doctors, who used to serve fewer patients, and work with fewer diseases. More and more patients are now going to the

Research showed that in markets like Singapore and South Korea, some 14% of health-care jobs will become more efficient and productive due to AI.

clinics instead of higher-level hospitals, as the perception of service levels has significantly improved."

Satisfied with the progress thus far, Jiao would like to get more out of the CDSS tool, which could be used virtually to diagnose patients in remote areas and recommend which hospital and department they should visit. After seeing the doctor, the system could follow up with the patient to provide ongoing care recommendations, which would combine CDSS' current functions for supporting doctors with additional capabilities to advise patients about ongoing treatment or further care.

Explainable AI

By providing explainable suggestions, CDSS guides physicians through the clinical decision-making process like diagnosis, treatment plans, and risk alert. The interpretability of CDSS is built upon the medical natural language processing (NLP) and knowledge graph (KG) technology, two key factors that drive its ultimate success.

"The medical NLP and KG techniques lay the foundations of Baidu's AI health care. Automatically, NLP extracts critical entities, relations, and attributes from medical records as well as professional medical literature. They are then assembled together into the medical KG, which is a complex yet structural way to encode medical knowledge. This capability and process would not have been possible without close collaboration between medical experts and AI engineers," says Huang. Multiple AI health-care products are then developed based on medical NLP and KG, facilitating clinical decision-making with explainable suggestions.

04

Keeping pace with machines

Rapid advancements in medical imaging technology, coupled with the analytics and machine learning capabilities of AI, have led to extraordinary advancements in the ability of Asia's health-care professionals to quickly diagnose serious conditions.

There are several factors that have contributed to these big gains in capability. The first is investments made in medical imaging. Across Asia, nearly $400m in venture capital investment went toward medical imaging ventures in the first half of 2019, out of nearly $2.5 billion in overall health-care technology venture funding.[4] Research firm IDC estimates that spending on technology by Asia's health-care sector may reach nearly $15 billion by 2022, a 7% annual increase from today's levels.[5]

The second area of progress is in the substantial digital data sets being built around certain diseases and injuries. Digital data sets—while definitely patchy across the region as a whole—are becoming increasingly robust in China, South Korea, and Japan, and these large archives of CT and MRI scans are providing the fuel for machine learning algorithms to identify patterns, interpret ambiguity, and make diagnoses with impressive accuracy. As new data sets emerge, so too will new AI models for detecting diseases. In Korea, imaging startup Lunit recently received Ministry of Food and Drug Safety approval for its breast cancer detection platform, based on an algorithm trained with over 200,000 mammogram images.[6]

Human-machine diagnostics

Medical imaging capabilities have exploded in the past decade, which offer great assistance to medical

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> CEO, Wadhwani Institute for AI

professionals in diagnosing diseases, but also greatly challenge the skills of doctors to diagnose images correctly. "Medical image diagnosis has uniquely flourished as an AI health-care application over the last six or seven years due to a confluence of factors," says **Padmanabhan Anandan**, CEO of India's Wadhwani Institute for AI, "such as the volume and availability of digital images, and the increasing interpretation performance of machine learning tools, which has far exceeded human capabilities."

Anandan describes image interpretation as a challenging category of medical analysis. "Medical images are 'noisy', and the inferences generated require subtle interpretation," he says, making them well-suited for the diagnostic assistance of complex analysis tools, as opposed to chemical analysis (of blood tests or biopsies, for instance), where doctors can more easily interpret quantitative results.

Xu Shan, director of International Cooperation Department, Medical Big Data and Network Research Center of the China Academy of Information and Communications Technology (CAICT), and vice-chair of the ITU (International Telecommunication Union)/World Health Organization's Focus Group on Artificial Intelligence for Health (FG-AI4H), agrees that medical imaging is a particularly impactful use case for AI innovation, in part due to what she sees as a powerfully unique combination of computer vision and deep learning technologies. "Multidimensional image fusion processes"–which combine important data from several recorded images into one–"can enhance the accuracy of lung cancer detection by 50%, and convolutional neural networks (neural networks designed specifically to detect and interpret pixel data) enhance the power of diagnoses," says Xu.

In bringing these technologies to bear on image analysis, efforts in Asia are not necessarily unique. "Cancer is cancer, all over the world," observes **Kazumi Nishikawa**, director of Japan's Ministry of Economy, Trade, and Industry (METI) Healthcare Industries Division. That said, Asia's depth of experience and large data volumes do offer an advantage. China, for one, is building competencies thanks to a huge volume of medical image data and the country's early lead in a variety of image recognition tools, particularly facial recognition.

Nishikawa points out that medical image analysis is a skill that is particularly strong in Japanese hospitals and universities. "You can find (image diagnosis) projects all over the world, but Japan is unique for the large number of images generated and the quality of doctors providing tags and teaching resources for AI platforms." In 2017, Japan's National Institute of Informatics, the Agency for Medical Research (AMED), and other medical academic organizations launched the Research Center for Medical Big Data, a national cloud-based medical imaging R&D initiative. Japan also has the highest density of CT and MRI scanners among OECD countries.[7] Nishikawa sees increasing academic collaboration opportunities emerging between Japan's Medical Big Data AI research and other medical systems globally, and notes that AMED is looking to enlarge the program to transition it from research to commercialized diagnostic tools.

Bridging the data divide

Governments of Asia's emerging economies are mostly yet to set out specific provisions for developing AI in health care, typically because there are other challenges that take precedent. Anandan at the Wadhwani Institute for AI points to India as an example. When the country's National Digital Healthcare Blueprint was launched, "AI was not even accounted for," he says, since "platforms for data collection and analysis of patient information need to be built first." In this regard, AI could be part of the answer, says Anandan, as machine learning tools can "filter and clean data, making it flexible and accessible, and ensuring patient data is used and shared securely."

India also has other unique resources in addressing this data divide, such as its world-leading IT enabled service sector. "Indian IT is not only the back office for the world, but for India as well," Anandan observes. Indian IT companies are already setting up data ecosystems for a host of Indian government infrastructure initiatives, and the digital health-care objective presents one more opportunity for them.

India's overall lack of digital health infrastructure belies significant pockets of wealth and health-care expertise. "A good chunk of India cannot be called developing anymore," explains Anandan. India's medical resources at a national level are poorly distributed per capita, in terms of human capital, facilities, and infrastructure, "and most poor areas are largely served by health-care professionals who are not fully-trained. Yet we also have good middle-class care coverage." This mix, he believes, offers a unique opportunity to explore AI use cases for both ends of India's socioeconomic spectrum.

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05

Targeting country-specific health challenges

Health-care advances using AI have been particularly successful in Asia, where they have tackled a pernicious medical challenge while also leveraging a country's unique assets—skills and talent, or data resources. As discussed in the previous chapter, directing AI with large data sets such as medical images has led to incredible advancements in the diagnosis of cancers, strokes, heart attacks, fractures, and eye conditions, and the list is growing rapidly. There is also a significant opportunity for Asia's less developed economies to harness AI for tackling their own specific health burdens, such as maternal and newborn mortality, or tuberculous, in India.

In China, a range of health-care challenges for its large population is complicated by the country's growing wealth and access to convenient digital services. This creates rising expectations on health-care facilities which further strain their limited capacity. Finally, aging is rapidly becoming one of Asia's leading health-care crises, typified certainly by Japan, where nearly one in three people are aged over 65. The rest of the region is not too far behind. By 2030, more than 25% of South Korea, Thailand, and China's population will be over 60 years old. Over the coming decades, government policy and private sector innovation will combine to develop specific AI applications to address all these unique challenges, and more.

Reducing infant mortality in India

Wadhwani Institute has identified maternal and child health as a key area for AI development. India's Central Bureau of Health Intelligence reports that while the infant mortality rate has more than halved over the last two

decades, from 74 per 1,000 live births in 1994 to 34 in 2016, this is still six times greater than in the United States, which at 5.6 per 1,000 is still the worst-ranked among developed nations.[8,9] "Neonatal risk management is a high priority for the country, and as a result there is also a lot more historical data available," says Anandan, "which provides an opportunity to use AI for stratifying maternal risk." Wadhwani has begun experimenting with an AI smartphone app to capture data about newborns.

While there is a lot of statistical data, Anandan notes that most of it is not well-gathered, as "measuring newborns accurately outside of health-care facilities is difficult: head size needs to be measured in a certain way, and in a certain timeframe. Some 30% to 40% of babies are incorrectly weighed at birth, and low-weight births in particular tend to be 'guesstimated.'" Wadhwani's project involves "a few smartphone photos and a 3D virtual model driven by synthetic data," to establish "ground truths" that can be built upon for a fully-fledged field trial later this year.

Accurate measurement data may remove one of the biggest hurdles in using AI to lower infant mortality, Anandan notes, but Wadhwani's project "must now take a step backwards" to more fully stratify infant mortality risk, incorporating and analyzing data on community factors and pregnancy health indicators. He sees potential for similar AI development in other health areas "where India has a deep footprint of national-level resources that collect data and work with state governments." Areas such as tuberculosis "will be the vanguard of India's primary care investments in AI," he says.

At the premium end of India's health-care spectrum there are opportunities to enhance efficiency, as well as patient outcomes. One example is in providing AI second opinions for risky elective procedures, such as cataract surgeries, which Anandan says have dramatically increased in the wake of India's new health-care insurance policies. "Many cataract surgeries are not strictly needed, but it is often difficult for a health-care professional to clearly determine that," he says.

Japan's AI silver lining

One area of AI research in which Japan has a particular home market advantage, according to Kazumi Nishikawa, director of Japan's Ministry of Economy, Trade and Industry

(METI) Healthcare Industries Division, is the development of solutions to care for its fast-growing elderly population. Nowhere else in the world is the graying of a society more acute: in 2006, the country became the first nation where 20% of the population was above the age of 65. Today, that percentage is over 28%—more than 33.6 million people, according to the country's National Institute of Population and Social Security Research, which forecasts will grow to 37.7% by 2050.[10]
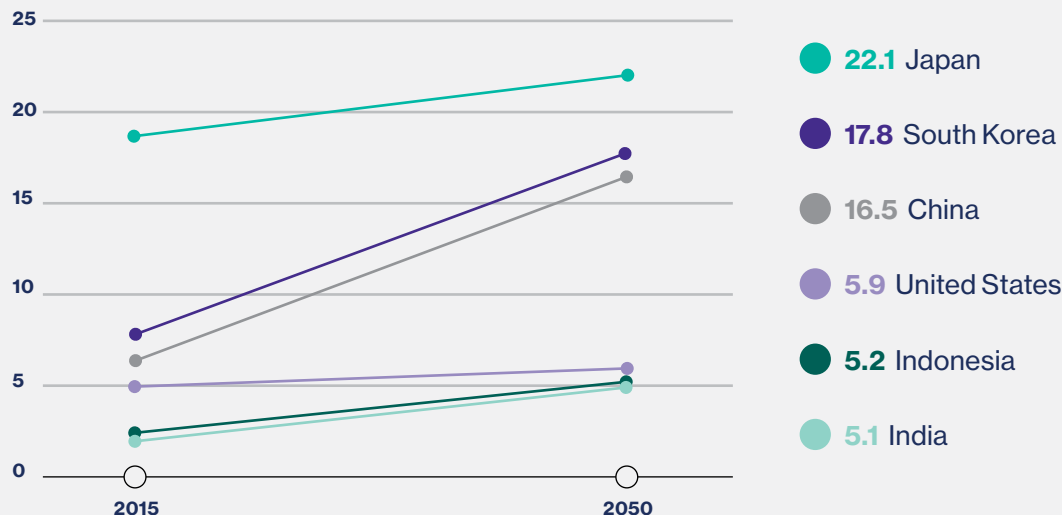
While longer-term forecasts stabilize from that point forward (38.4% by 2065) this has more to do with the speed at which the nation's population is decreasing overall: Japan's total population has been in decline since 2011, and

Aging is rapidly becoming one of Asia's leading health-care crises. Closely following Japan, by 2030, more than 25% of the populations of South Korea, Thailand, and China will be over 60 years old. Over the coming decades, public and private sector innovation must combine to solve the challenges this demographic shift will bring.

Figure 6: Demographic trends in China, 2005-2033

Total births
Total deaths and emigration
Total population
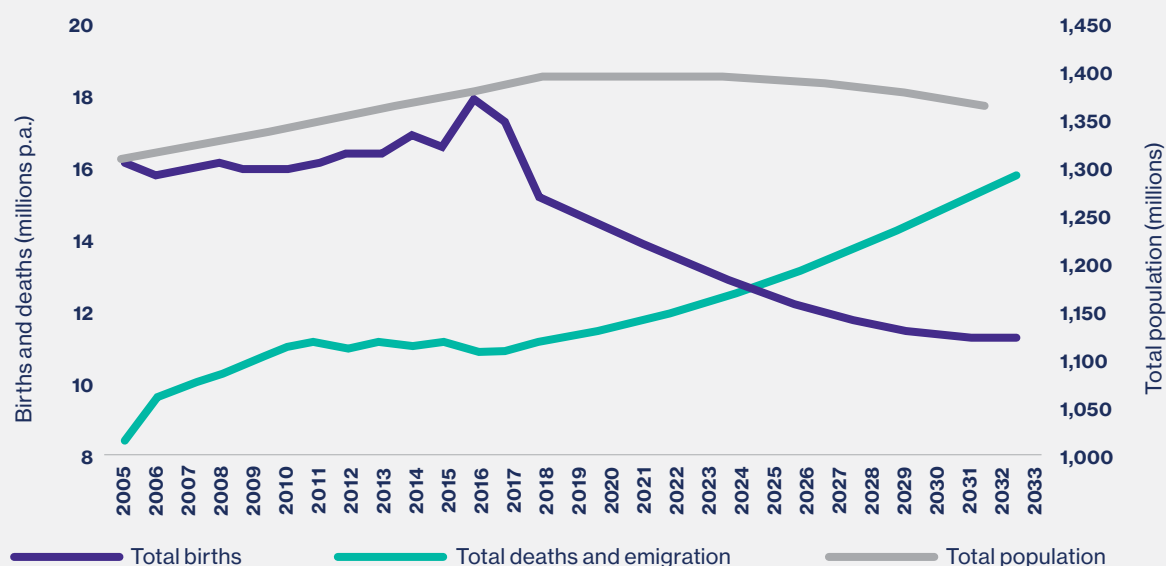
Source: Complete Intelligence, 2018

Figure 7: Public spending on the elderly (% of GDP), 2015-2050

- **22.1** Japan
- **17.8** South Korea
- **16.5** China
- **5.9** United States
- **5.2** Indonesia
- **5.1** India

Source: Nikkei Asian Review, based on data from S&P Global, 2016

Japan's Ministry of Internal Affairs estimates its native population shrank by 430,000 last year.[11] The financial burden of the gray population is high, with over-75-year-olds costing the government four times as much as other citizens. At the same time, the base of people that can care for (and pay for) its elderly swiftly shrinks.

Against this backdrop, a sizable number of startups in elder care are emerging to create "really unique AI for Japan," says Nishikawa. These include communication tools for patients with dementia, and predictive analytics for helping caregivers schedule toilet breaks for patients. While the data is not as readily available as in medical imaging, Nishikawa says that recording interactions with "grandma and grandpa" is rapidly helping these companies build data sets.

ExaWizards, a Tokyo-based startup founded in 2016, gathers data from cameras, microphones, and voice analysis systems in care homes and combines the data with principles from Humanitude—a French dementia care program that has been widely adopted in Japan. Humanitude's approach is to train caregivers in gentleness and kindness by communicating with dementia patients using voice and touch, eye contact, and maintaining respectful distances to improve psychological outcomes of both patients and nurses. Another innovation comes

In Japan a sizeable number of startups creating unique AI solutions for elder care are beginning to emerge. These include communication tools for dementia sufferers and predictive analytics to help nurses understand patient habits more easily.

from Triple W, another Tokyo startup with a US-based subsidiary that uses AI to analyze data from a small wearable ultrasound bladder device to help elderly people and their carers predict toilet times. According to Nishikawa, "In the last three years, more than 100 elder care homes have installed this system, and it is being exported to the US, China, and Europe."

Nishikawa notes that many Japanese AI companies may not have world-leading technology behind them, but companies like ExaWizard and Triple W are showing how his country's health-care startups can successfully leverage a globally competitive advantage: "Japan's high requirement for elder care makes me confident that Japan will continue to generate useful, unique AI applications," which will have regional and global impact. Japan's extreme aging crisis may be particularly acute, but it is by no means unique within Asia. Total births in China peaked five years ago, and at current rates, deaths and emigration will exceed births in China within another five years, according to research firm Complete Intelligence. China and Korea in particular are likely to see their elder care costs rise precipitously over the next two decades.

Singapore's Grand Challenge

Many Asian governments have long histories of developing industrial and social incentives to focus business investment and academic output on public policy issues. Singapore in particular has trained a portion of the country's collective energy and research in AI towards specific health outcomes.

In June 2018, AI Singapore, a promotional agency of the country's National Research Foundation, launched its "AI in Health Grand Challenge," inviting local academic institutions and businesses to participate in a contest to build AI applications that could contribute to the country's overall goal of reducing by 20% the number of patients with hyperglycemia, hyperlipidemia, and hypertension by 2024. These three diseases, collectively named the "Three Highs," are expected to affect 1.5 million Singaporeans—over 26% of the population—by 2020, according to the Ministry of Health.

In March 2019, AI Singapore awarded grants of S$ 5m (US$ 3.6m) each to three finalist project teams, and will invest up to S$ 20m (US$ 14.4m) in one single finalist at the end of two years. One of the finalist teams, dubbed JarvisDHL, is a National University of Singapore (NUS)-led initiative with plans to develop an AI platform, accessible by patients and health-care providers, that will allow them to monitor and evaluate health indicators linked to diabetes, high blood pressure, and cholesterol. A second initiative, also led by a NUS team together with Singapore's National University Health System, is aimed at developing planning and decision-support algorithms which extend the capacity of Singapore's Community Healthcare polyclinics, including FoodLg, which monitors patient nutrient intake and provides analysis and patient coaching. A third initiative looks at developing an assessment and intervention platform to assist "Three High" patient management from initial detection to treatment management.

06

AI and active health

As discussed in previous chapters, much of Asia's AI development emphasis is on increasing the capacity and capabilities of medical professionals and facilities, as well as solving specific local health burdens. But increasingly, policymakers, academics, and technologists across the region are investigating the potential for AI to radically redefine the very notion of health care. A new concept, becoming known as "active health," is emerging whereby health authorities will compile and categorize disease markers, risk factors, and other intelligence on disease and health conditions, and use it to make predictive recommendations for what people should do to improve their health.

"Active health" is a technology-enabled step towards proactive and preventative health management that could define the very notion of health care in the future. The ongoing convergence of AI and wearable devices will accelerate health-care providers' capabilities to predict and prevent the development of non-communicable diseases.

CAICT's Xu Shan points to health management and aging measures as main concerns for China over the coming years. China's Ministry of Science and Technology's 2018 Notice on a National Key Research and Development Plan on "Active Health and Aging Technology Response" is "one of several key special project declaration guidelines China will be introducing over the next four years in areas that are most promising." She identifies several health-adjacent technologies, including deep learning applications for AI, virtual assistants, wearable monitoring, and multi-heterogeneous data analysis, as well as data processing (labeling and quality control), as industries that will grow quickly in China over the coming two to five years.

Lessons from Bian Que
Xu believes that this new technology focus will catalyze a leap from reactive interpretation of presented data (that is, suggesting a diagnosis based on the review of an MRI scan) to AI applications which, empowered by deep neural networks and even deeper data lakes, make predictive recommendations on patient behavior and treatment for optimal health.

She illustrates this objective using a folk tale of Bian Que, a legendary physician in the Zhou dynasty (circa 500 B.C.) who is often considered China's first notable medical professional. Bian Que had two brothers who were also doctors, and according to legend, Xu explains, "A king asked Bian Que, the most famous of the three, which one was the best doctor. Bian Que replied that he himself was only average, and only the most famous because he treats people who are already very sick, so the effects of his treatment are well-observed. His second brother, Bian Que explained, was better, because he treated people at the first sign of a disease, when they were only a little sick. His eldest brother was the best doctor, because he saw what could make them sick, and treated them before they even felt bad."

Wearables + AI

Across Asia, wearables are seen as part of this new focus on active health. The region is already the world's largest market for wearable devices, with revenues estimated at $7.3 billion, dominated by China (at $4.6 billion) and India (at $1.4 billion), and growing at roughly 4.4% annually.[12] Asia's manufacturing sector is also the epicenter of the world's largest consumer electronics ecosystem. As a result, there is a burgeoning health-care sector in Asia that is focused on building AI-enabled tools and devices. The DFree toilet timing assistant developed by Japanese startup Triple W is an example of how wearables and AI technology converge to create an active health tool.

Xu believes it is in the ability to predict and advise based on indicators and conditions prior to medical events "that the true transformative power of AI applications in health care will be realized." This shift from reactive or interpretive AI will partly be driven through deeper insight into existing conditions. Already, intelligent wearable devices can transmit information to analytics systems, which can recommend exercise, diet, and medication regimes, and keep constituents abreast of how effective they are in following those regimes.

Other examples of Asian innovation in wearables include Hong Kong-based Well-Being Digital that has over 50 patents for its sensitive and accurate heart-rate monitors that can be used in earphones and any number of wearable devices, and Singapore's Health Promotion Board partnering with Fitbit to launch a nationwide healthy living campaign which will see free health monitors distributed to citizens.[13]

No substitute for a human

Yet even with this convergence, the transition to active health AI will be difficult, observes Nishikawa at METI. "I am optimistic that AI can help make people healthy; in Japan and all over the world people can easily deploy a combination of wearables, applications, and analytic systems to give incentives for making healthy lifestyle choices. However, I am not optimistic that AI will serve as a reliable substitute for the diagnostic services of a doctor, for a combination of reasons: accuracy, credibility and, most importantly, responsibility. A medical doctor must be responsible for their own diagnosis, including the responsibility to manage a patient's anxiety levels" when presented with an unfavorable diagnosis.

"In this sense, we must be conservative in applying AI capabilities as a complete substitution. Diagnostic support systems today must supplement and support doctors." The next logical step toward more active AI, Nishikawa believes, is in leveraging AI to fully support health-care professionals in specific contexts. He points to Tricog, a Singapore-based health-care company that has attracted investment from the University of Tokyo's Edge Capital venture fund. Tricog's technology links electrocardiography machines operated by clinics and hospitals in over a dozen countries in Africa, south Asia, and southeast Asia to its cloud analytic platform, sending electrocardiogram results for analysis and interpretation by its own medical team. The company claims that this combination of remote expert- and AI-enabled diagnostic support can provide customers with results in six minutes. The value of Tricog's approach, Nishikawa says "is in providing doctor-to-doctor predictive services, to other professionals in countries where professionals have less experience."

AI should not fully substitute the diagnostic services of a doctor for three reasons: accuracy, credibility, and most importantly, responsibility.

07 Conclusion: Matching urgency and ability

This report, "AI in health care: Capacity, capability, and a future of active health in Asia" has explored how emerging technologies are being used to meet the specific health-care needs of Asian countries, and how the region is fast becoming a global leader in health-care technology innovation. These areas of innovation include the efforts to accelerate AI diagnosis in medical imaging in Japan, in the use of AI to build capacity and overcome a lack of infrastructure in China, and in the government goal-setting for three high-burden conditions in Singapore.

The conclusions of the report are:

AI is rising to meet health-care challenges in Asia
The strategies emerging across Asia, to match AI capabilities with a country's unique challenges and health requirements, are creating fertile environments for innovation. Governments can take an even more active role in setting audacious goals for private sector and academic research, as well as developing interesting models for collaboration with different players to find new solutions for health-care needs. Singapore's Grand Challenge is an example of how governments can foster targeted R&D as well as providing the necessary resourcing.

Solve the hardest challenges first
Asia's health-care players—whether governments, providers, or tech companies—should focus on the most challenging and widely experienced issues in domestic and international health-care markets. The list of such candidates is seemingly endless, but the most efficacious efforts combine the identification of a large-scale problem—such as rising dementia care requirements in

Japan, which already afflicts 4% of its population—with AI resources. Working to enhance resources and personnel will yield immediate results, as well as lay the groundwork for future breakthroughs.

Encourage innovation, but ensure ongoing evaluation
While pursuing innovative solutions to health-care challenges is important, Xu at CAICT also notes, "The real path towards transformative health-care AI lies in ensuring that these innovations are heavily benchmarked and evaluated, which can be helpful to ensure compliance with pre-market and post-market regulations. Successes in building domestic capabilities will be tremendously helpful for other markets, and create opportunities that can be exported regionally and globally." China and Japan's increasing lead in image recognition technologies is already providing tech export opportunities.

Keep humans at the center
The increasing contribution of technology to medical decision-making is undoubtedly a benefit to countless patients across Asia. Yet it is ethically imperative that technology maintains a supporting role to the expertise of human doctors and practitioners. Final decision-making responsibility must continue to lie with humans, to guarantee accountability in the health-care system. The innovations that emerge to enhance the capabilities of doctors by increasing their medical expertise and ability to treat patients effectively and quickly will be among the most transformational in Asia. For patients at the top of the economic pyramid, the quality of care is already high. But for the millions of people lower down the socioeconomic strata, having greater access to efficient and experienced medical professionals will be immeasurably beneficial to the quality of their lives. ∎

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