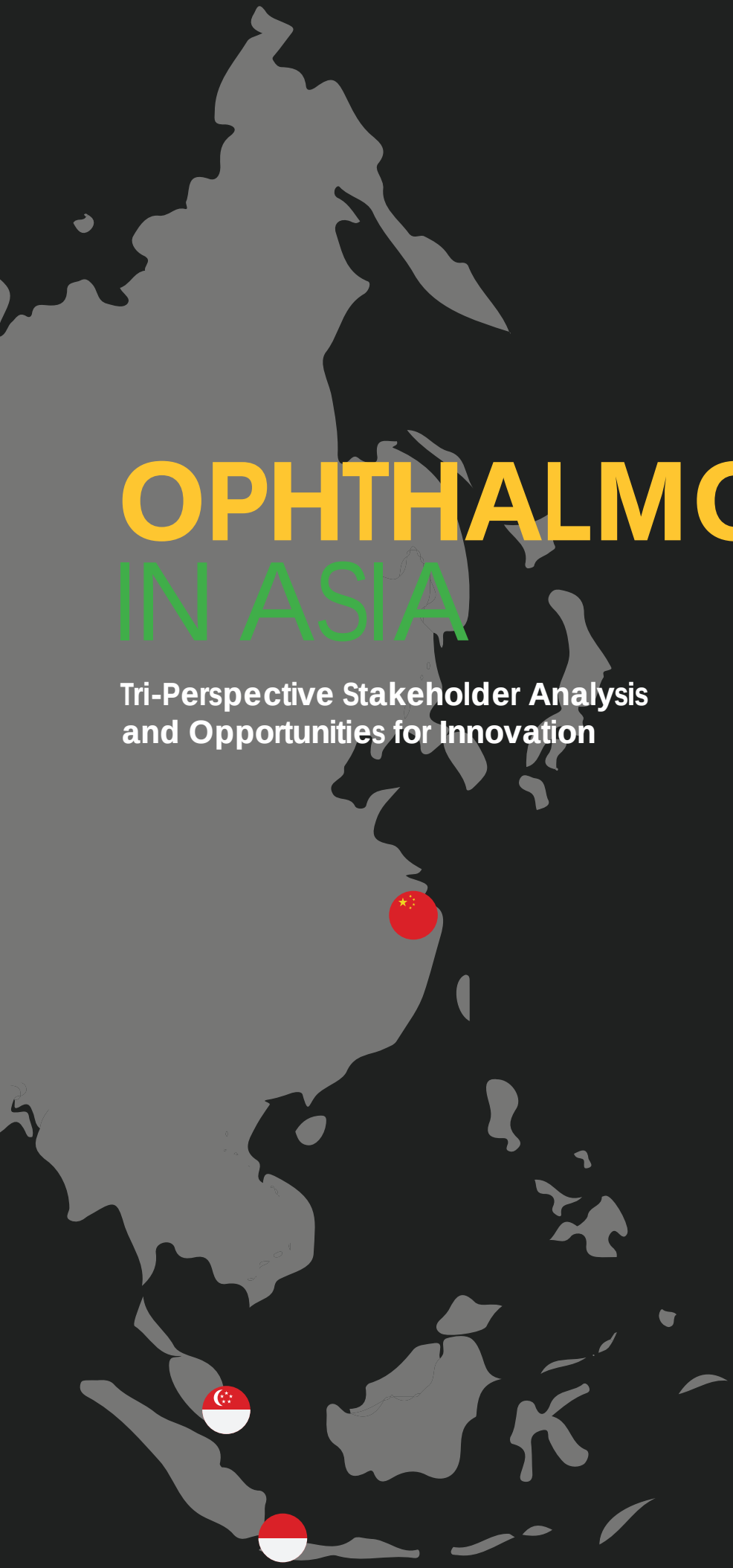
SINGAPORE BIODESIGN

OPHTHALMOLOGY IN ASIA

Tri-Perspective Stakeholder Analysis and Opportunities for Innovation



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Foreword from the Programme Director

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In this first half of 2020, with global health systems consumed with the fight against the coronavirus pandemic, one might be forgiven for overlooking the advancements and innovations happening today in other medical fields, like ophthalmology. Yet even as many healthcare systems shift their immediate focus to caring for the urgent challenges posed by the COVID-19 disease, the needs of ophthalmology patients have not abated and solutions are needed for many devastating conditions.

As in so many other areas of medical specialties, the Asia Pacific region is playing a growing role in the global efforts to develop a continuum of new medical technologies, therapeutics, and solutions for eye diseases. Singapore has also established its reputation and track record as a global hub for eye research, with public and private sector investment in ophthalmology R&D on the rise.

This uptick in activity is driven partly by need. The Asia Pacific region is home to an outsize share of the global population suffering from moderate-to-severe vision impairment and preventable blindness. In the case of some eye diseases, such as myopia, primary angle closure glaucoma, and diabetic retinopathy, Asians are particularly susceptible due to genetic, cultural, and behavioural factors. Across the region's developing markets, the challenge is exacerbated by major gaps in access to quality ophthalmological care.

These challenges were a major reason why Singapore Biodesign, a national healthtech innovation talent development programme hosted within the Agency for Science, Technology and Research (A*STAR) in Singapore, chose to make ophthalmology the key focus of its Biodesign Innovation Fellowship Programme in 2019. As in previous years, the programme recruited a multidisciplinary team of fellows to conduct research and clinical immersion in Singapore, China and Indonesia to better understand the ophthalmology needs in the region.

We were fortunate that our 2019 Fellows—David Chen, Jia Yun Hee, Bryan Ho, and Preeti Mohan—were able to complete their research before much of the region went into lockdown. Their initial findings were presented at our annual Thought Leaders Series event in October 2019, which brought together some of the world's top experts in ophthalmology and innovators from across Asia to share best practices and reimagine the future of eye care in the region.

This white paper is a follow up to our first instalment of the series on 'Diabetes in Asia' where we share the needs-centric approach to understanding issues on the ground in greater detail with the broader Asian healthcare community. While the priorities of many healthcare systems have changed dramatically in recent months, the research is just as important as it was when the Fellows started on it last year. Some of the technologies they discuss, including those that "decentralise" ophthalmology care by enabling remote diagnosis and consultation for various types of eye disease, may have even greater resonance in a post-COVID-19 world.

We hope these insights prove valuable for all members of Asia's vibrant ophthalmology community as they continue their work to address the region's many unmet needs. Above all, we hope you all stay safe and healthy in these challenging times.

About the Authors

SINGAPORE BIODESIGN 2019 FELLOWS

MR DAVID CHEN

DAVID is an innovative problem-solver with experience across the medtech value chain, from engineering to entrepreneurship. He invented a patient transfer device for caregivers, which won the NUS Medical Grand Challenge, and co-designed a glaucoma treatment tool, which is in developmental stage. In his past role as a manufacturing engineer in Resmed, he validated new processes for product launches and designed new methods to automate production lines. As part of the SB team, he planned business strategies and consulted for a pre-spinoff project on market analysis. David now serves in clinical engagement to enable development and marketing efforts in a local startup, striving to bring innovations from the bench to bedside. He graduated with a B.Eng (Hons) in Mechanical Engineering from NUS.

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JIA YUN is a mechanical engineer who is passionate about product design and development. In her role as a mechanical engineer in Biobot Surgical Pte Ltd, she was in charge of designing a significant portion of the next-generation surgical robot and accessories. This involved generating product requirements and specifications, design, prototyping, and verification. She has also participated in streamlining engineering processes, preparing documents for regulatory submission, and managing patent applications. She is a certified Solidworks professional, proficient with various prototyping tools, and has a strong interest in electronics and software. She aspires to be a leader in medical device product development in order to address pressing clinical needs. She graduated with First Class Honours in mechanical engineering (M.Eng) from Imperial College London.

DR BRYAN HO

BRYAN is a clinician-innovator with a keen interest in bringing innovative medical technologies into clinical practice. He currently works as an Associate Consultant in Radiation Oncology at the National Cancer Centre Singapore, specialising in the treatment of breast and haematological malignancies. During his specialty training, he became a Fellow in Clinical Oncology of the Royal College of Radiologists (UK) in 2018, and received his specialist accreditation the following year. Prior to his medical training, Bryan was involved with several engineering projects related to biomaterials, drug delivery, and medical device development. He graduated with a B.Eng in Bioengineering from the National University of Singapore, and holds a M.D. from Duke-NUS Graduate Medical School.

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SINGAPORE BIODESIGN – WRITER IN RESIDENCE

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WILL is a healthcare writer, entrepreneur and strategy professional with 10+ years of experience in Asia. He currently serves as Healthcare Engagement Manager for Roche Diagnostics Asia Pacific, where he focuses on building new digital services and helping to reimagine the future of the clinical lab. Prior to joining Roche, he ran a consulting practice that served healthcare and technology organisations in Asia, including many of the region's top biopharma and medtech firms, as well as innovative start-ups, trade associations, NGOs, universities, and research institutes. He earned a B.A. with honours in Political Science from Amherst College.

OPHTHALMOLOGY IN ASIA:

A Regional Overview

Vision is key to life. It plays a central role in helping us navigate the world, engage in new experiences, and communicate with our peers. The ability to see is so important that many people fear blindness more than life-threatening diseases like cancer and AIDS, or other debilitating conditions like loss of limb[1].

While widely feared, vision impairment and blindness remain a massive problem around the world. There are at least 2.2 billion people with vision impairment[2] caused by eye diseases such as cataract, glaucoma, diabetic retinopathy, and uncorrected refractive error. This results in an economic burden of US$2.8 trillion dollars of direct costs globally[3].

The Asia Pacific region contributes disproportionately to the global burden of vision impairment and eye disease. Nearly two-third of patients with moderate-to-severe vision impairment come from East, South, and Central Asia, even though the population of these regions accounts for only 51% of the global population[2]. The majority of these vision impairments come from conditions that could have been prevented or are yet to be addressed[2].

Myopia is one of the leading causes of preventable vision impairment in Asia. It is present in more than 80% of young adults in Singapore, South Korea, and China[4], even as incidence of the condition in many Western countries, like Australia, Europe, and United States, is increasing rapidly but closer to only 20%. The mechanism of onset and progression of myopia is not fully understood, but existing evidence highlights risk factors like parental myopia, ethnicity (Asian/East-Asian populations have a higher risk and prevalence), age of onset, refractive error at base line, and lifestyle/behavioural factors like time spent outdoors and amount of near-vision activities[4] during the developing age in children.

In fact, due to increasing work-from-home, home-based schooling and social distancing, children and adults are spending longer hours in front of screens and doing near work, which may have long term eye-health challenges at a population level. The Singapore government is aware of these challenges and working to address them. It has one of the world's most prominent National Myopia Management programmes, and in 2018, the Singapore Eye Research Institute/Singapore National Eye Centre and Johnson & Johnson Vision, announced a Joint Myopia Research Collaboration, a first-of-its-kind public-private partnership programme with a joint funding of SG$36 million[5].

Angle-closure glaucoma is another eye disease that is particularly common in Asia. Up to 77% of angle-closure glaucoma patients reside in the region[6]. The disease is also disproportionately aggressive, contributing to nearly half of the world's glaucoma-related blindness despite comprising only 23% of all glaucoma cases[7]. Genetic factors play a role, as Asians tend to have smaller eyes and shallower anterior chambers than Caucasians[8].

Like myopia and angle-closure glaucoma, most of the eye diseases that are common in Asia can be attributed to a variety of factors that will be explored further in the following sections.

Our Approach

The Biodesign Innovation Process is a robust multi-disciplinary and systematic approach for the identification of important unmet healthcare needs, the invention of novel technologies, and the implementation of business and commercialisation plans to bring them into patient care. It is adapted from the concept of design thinking, which defines a given problem from the user perspective and implements solutions with the user demographics at the core.

To better understand the nuances of ophthalmology management in Asia, the Singapore Biodesign Fellows spent 12 weeks conducting clinic-based immersive observation and interviews at various healthcare institutions in Singapore, China, and Indonesia. During this process, the Fellows were exposed to a range of healthcare settings, including community clinics and tertiary hospitals in various districts and settings. The goal was to obtain on-the ground insights to inform solutions for unmet medical needs.

This white paper presents a snapshot of ophthalmology trends in Asia through the lens of three stakeholder groups: patients, providers, and payers. This tri-perspective framework provides key insights into the challenges faced by these stakeholders, as well as opportunities for innovation. Please note, however, that this research is based primarily on a limited set of site visits and expert interviews over the course of several months, and is not meant as a systematic overview of ophthalmology care in each country.

PATIENTS:

Improving Disease Awareness and Prevention

Compared to patients in many other parts of the world, Asians with eye disease and vision impairment tend to be less proactive in seeking treatment. Asian patients are deterred by an array of barriers that include poor health literacy and cultural factors. Both digital and offline solutions are being deployed across the region to address these barriers.

Cultural and Educational Barriers

In many Asian countries, patients do not have sufficient health literacy to recognise signs of eye disease or navigate treatment options. A study in Indonesia, for example, showed that there was a significant lack of awareness of eye conditions, especially among individuals with lower education and income levels[9]. Similarly, a 2018 study in China indicated that poor understanding of long-term medication adherence had a negative impact on treatment outcomes for patients with glaucoma and cataract[10].

Across the region, cultural factors also contribute to high incidence of eye disease. In Singapore and China, for example, children spend a large portion of their time indoors studying and on screens. While myopia has multiple causes, some researchers believe the pressure of an intensive education system[11] forces limited outdoor play and excessive near work, contributing to the prevalence of this sight-threatening condition.

Cultural factors may also discourage Asian patients with eye diseases from seeking care. Despite poor and deteriorating vision, many patients do not feel they need to be concerned as long as they are able to get by with their day-to-day activities. They may accept poor vision as part of the aging process, as opposed to thinking of it as a condition that can be treated. This happens even in cases that are preventable or treatable, such as uncorrected refractive error and cataracts, which account for more than 70% of low vision and blindness in the region[12].

Even among patients with sufficient health literacy to seek treatment for eye diseases, many Asian patients are deterred by high costs and complex referral pathways. In addition, patients in remote or rural areas face especially daunting challenges and often need to travel many hours, together with a caregiver, to the nearest town just to gain access to a hospital[13,14].

Innovations Addressing Health Literacy

Since patient awareness and education is key to preventing and managing any eye diseases[15], programmes that drive behavioural change in the community setting have high potential. Social media is increasingly proving to be an effective tool for patient engagement. In China, for example, many community hospitals and tertiary care centres use WeChat as a way to engage patients and disseminate key health information related to treatment and monitoring.

Some innovators are employing novel apps for preventing and managing eye conditions. One example is Plano, a Singapore-based start-up that creates digital tools to promote eye health and responsible smart device use. The company developed a product ecosystem to mitigate excessive device usage and myopia among children worldwide. This includes an app for parents to manage their children's device use and eye health, as well as an online platform to find their nearest Plano-partnered optometrist and manage appointments.

Even in our digital world, traditional media can play an important role in driving behavioural change. For instance, Plano published a five-part illustrated children's book series about topics such as excessive screen time and myopia, the benefits of spending time outdoors, gaming disorder and device dependency. The Singapore National Eye Centre (SNEC) helped produce a children's book 'Amanda the Panda' that encourages outdoor play to preserve vision.

Singapore start-up Plano's app to promote eye health (left) and its children's book series (top right) to address excessive device use, outdoor activity for myopia, gaming addiction, cyber bullying and device dependency; SNEC's children's book to encourage outdoor play (bottom right).

PROVIDERS:

Decentralising Care to Bolster Access

While some Asian countries have better infrastructure and a more skilled healthcare workforce than others, many struggle to provide high-quality tertiary care at scale. The result is overcrowding and long waiting times for ophthalmology services. New products and business models can help to decentralise ophthalmological care and make it more widely available.

Infrastructure Constraints and Capacity Gaps

Despite efforts to build infrastructure and capacity in recent years, tertiary eye care centres across Asia face major overcrowding issues. At leading eye hospitals in Singapore, China, and Indonesia, the Fellows observed caseloads of at least 50 patients per day for most consultant teams (Figure 1).

Overcrowding at tertiary eye care centres was a particularly serious issue in China. Waiting areas were so crowded that they often spilled over into the examination room. In Indonesia, many patients started queuing as early as 6:00 AM to get a jump on the line. Across all three countries, long waiting times were the norm. On average, only 10-20% of time spent by patients in tertiary eye care hospitals in the three countries was actually spent on investigation or consultation (Figure 2).

An overwhelming day-to-day caseload with severe backlogs can result in suboptimal care for patients as well as considerable stress for health workers. Reasons for overcrowding include the centralisation of talent, services, and equipment; higher insurance coverage in tertiary hospitals; and a tendency of some patients to seek care at tertiary hospitals for relatively simple procedures or consultations that could be addressed in a local setting. Regional eye care centres, by contrast, do not typically face the same overcrowding challenges, but many lack staff with sufficient training to address more complex conditions, such as retinal detachment. The staff typically are not trained for complex procedures related to problems like retinal detachment, and public insurance coverage is not designed to support these procedures being conducted in regional centres.

Given the much higher case load, ophthalmologists in tertiary hospitals have more practice with treating a variety of conditions and more opportunity to hone their microsurgical skills.

Moreover, tertiary hospitals in urban areas usually provide better opportunities for training, income, and career progression. In China, for example, 70-80% of qualified ophthalmologists are in big cities[16,17].

The practice of ophthalmology also has a heavy reliance on a series of comprehensive eye examinations that require expensive and bulky capital equipment for diagnosis, treatment, and monitoring. For example, a regional centre may not be able to afford standard equipment like slit lamps and visual field test machines for glaucoma diagnosis and monitoring. In an ophthalmologic equipment survey of twenty-three hospitals in Southeast Asia, 60% of the hospitals do not have a photocoagulation laser, a primary intervention of vision-threatening diabetic retinopathy[18,19].

FIGURE 1

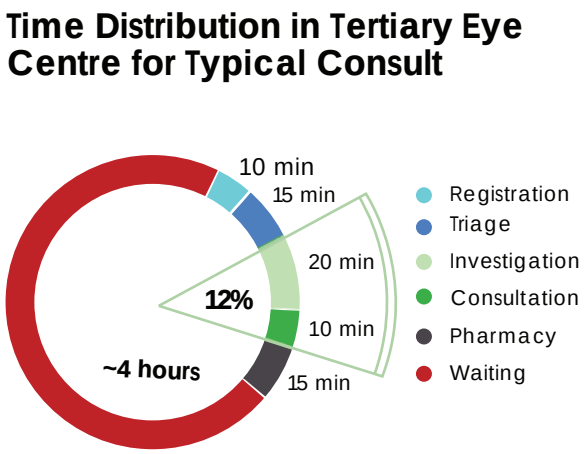
Average Caseloads at Tertiary vs. Regional Eye Care Centres

	Tertiary eye care	Regional eye care
	40 – 60 patients	N/A
	60 – 100 patients	20 – 30 patients
	60 – 100 patients	10 – 15 patients

FIGURE 2

Breakdown of Time Spent by Patients in Tertiary Eye Care Centres

	Time spent in hospital	Minutes per consult
Tertiary	2–4 hrs	12–20 min
"Province" 3A	3–5 hrs	3–10 min
Class A	8–12 hrs	10–20 min



only ~10-20% of time spent adds to clinical value

Decentralising Ophthalmology Services

New business models and technologies show considerable potential to address the infrastructure and capacity gaps that persist across Asia. Many are oriented towards "decentralising" care by enabling remote consultations and monitoring of diseases. Others focus on empowering allied health professionals, such as optometrists and nurses, to perform some of the roles and procedures that are traditionally under the purview of ophthalmologists, such as administering intravitreal injections or monitoring stable patients on follow-up[20].

Several new devices and services are also helping to democratise access to the specialised expertise and tools necessary for ophthalmological care. Examples include Plenoptika, which produces handheld autorefractors for determining refractive error, and Lumedica, which is developing handheld optical coherence tomography (OCT) devices for examination of the retina. Many companies are also developing tools to perform AI-assisted diagnosis of diabetic retinopathy, which enables expert-level interpretation of acquired fundus images to be performed in a remote and scalable fashion.

These technologies will help enable virtual clinics, where patients undergo remote ophthalmic investigations for monitoring of eye disease that can augment remote clinical decision making with machine learning and artificial intelligence. Devices and technologies that empower patients to perform self-monitoring and management of their eye disease would enable earlier detection of disease progression and hence earlier intervention, leading to better overall outcomes. For example, if there were a better way for patients with wet age-related macular degeneration (AMD) to detect recurrence, they would be able to seek timely treatment rather than wait till the next follow-up with irreversible damage to vision.

PAYORS:

Reducing Costs and Streamlining Reimbursement

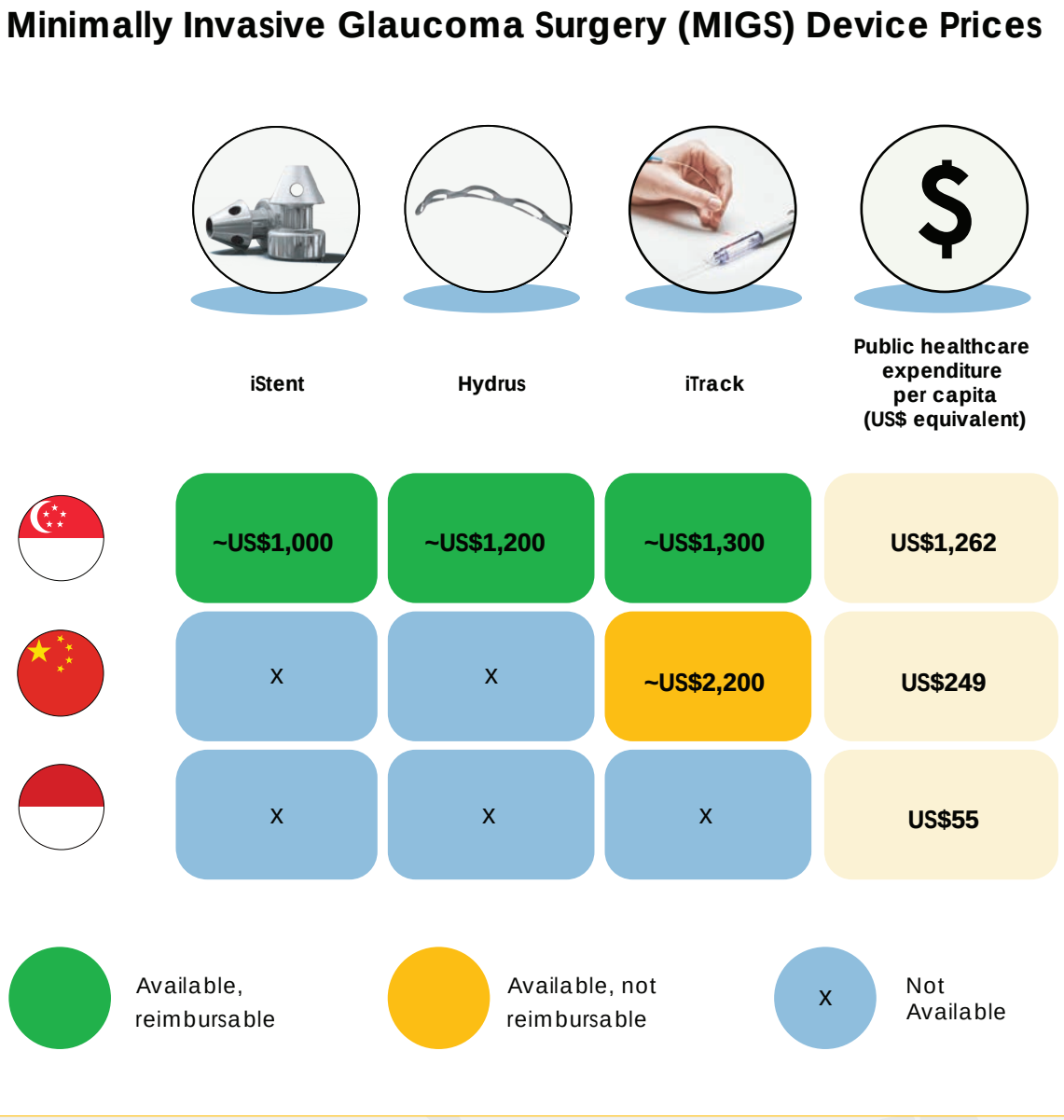
With the rise of universal health coverage (UHC) programmes across Asia, more patients are gaining access to care every year. Yet many of these programmes have limited resources and complex protocols for patients to access ophthalmology services. Smart management of public programmes and new private insurance products can make a difference.

Limited Public Coverage and Complex Referral Pathways

While many Asian countries are working towards UHC, their plans vary greatly in scope and service provision, with different degrees of out-of-pocket expenditures[21]. Coverage of the latest ophthalmological technologies and procedures is often limited. In the case of Minimally Invasive Glaucoma Surgery (MIGS), for example, availability and reimbursement levels for different technologies varies considerably across the region (Figure 3).

FIGURE 3

Availability and Local Price (USD) of Minimally Invasive Glaucoma Surgery (MIGS) Devices Approved for Market Use and Presence of Reimbursement vs Domestic Government Health Expenditure per capita in Singapore, China, and Indonesia[22]

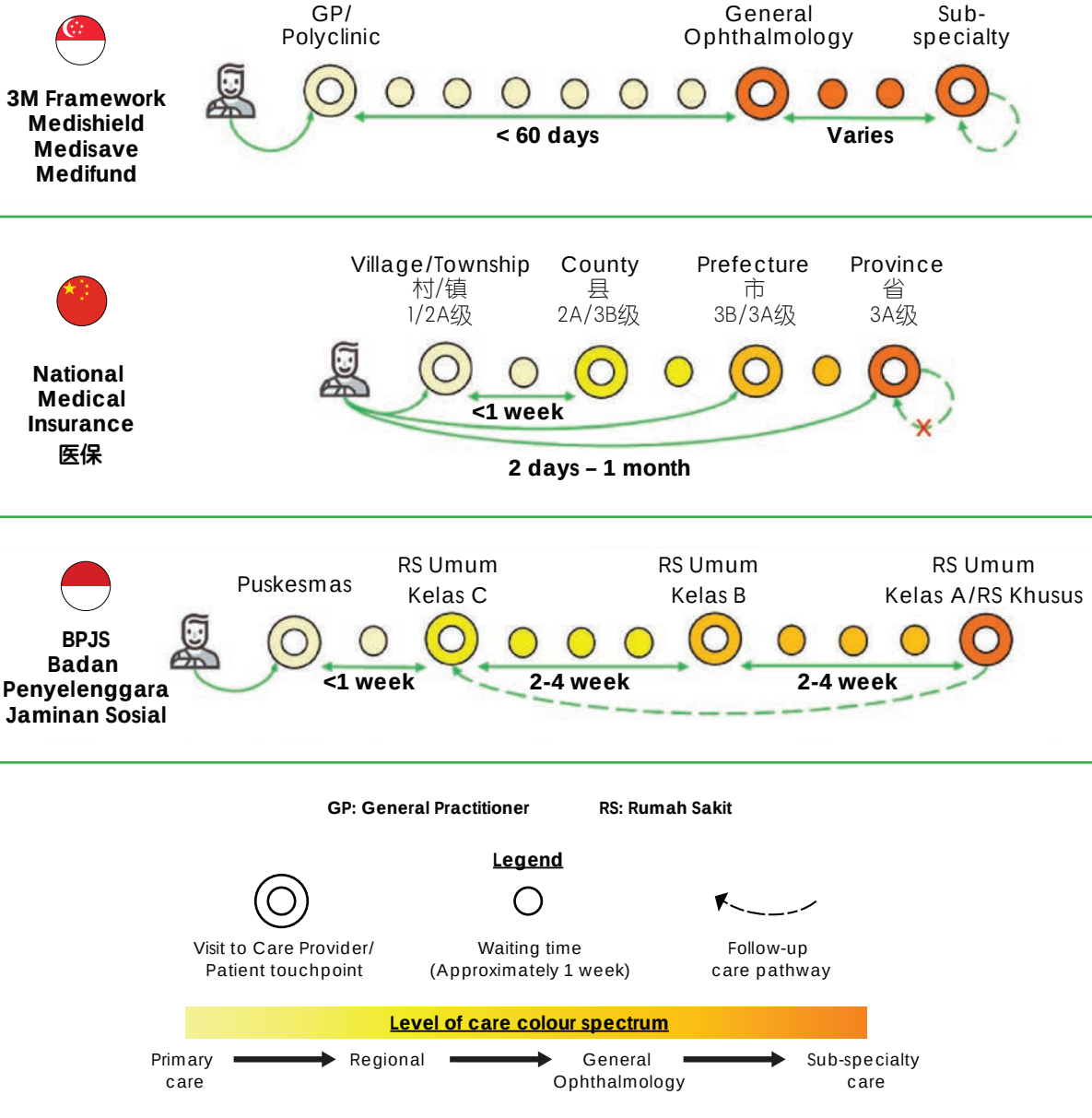


Moreover, most national reimbursement systems only cover the direct medical costs of surgery and medications. Patients in these countries may still have to cover non-medical costs like travel and lodging, as well as indirect costs from loss of income for the time spent seeking treatment. These costs may also extend to caregivers that need to accompany patients to appointments, thus increasing the total cost burden to a family or community.

Complex and suboptimal referral pathways under public reimbursement programmes present further barriers to many patients. These pathways, which differ significantly between countries, all have direct and indirect consequences on access to appropriate eye services and may affect clinical outcomes if diagnosis or treatments are delayed (Figure 4).

FIGURE 4

Reimbursement Policies Drive Complex Patient Referral Pathways



In Singapore, most patients receive an initial consult at a GP or polyclinic and are subsequently able to get a referral to tertiary eye care directly, where both general ophthalmology and subspecialty cases are seen. The lack of suitable primary or secondary eye care for de-escalation of care leads to the retention of patients within tertiary eye centres and hence overcrowding, which in turn has implications on waiting times for new patients.

In Indonesia, patients requiring subspecialty eye care have to follow a rigorous stepwise referral process from a community health centre to Class C, Class B and finally Class A hospitals as advanced procedures may only be covered by national insurance at tertiary centres. This process comes at the expense of time, leading to delayed initial intervention for ophthalmic emergencies such as retinal detachment and important follow-on procedures such as silicone oil removal. This in turn leads to significant rates of avoidable complications like secondary cataract and glaucoma due to the silicone oil left in *situ* (Figure 5).

Unlike in Singapore and Indonesia, most Chinese patients circumvent the standard referral pathway and go directly to a tertiary subspecialty eye care centre. This contributes to overcrowding at urban hospitals, even as regional centres remain underutilised.

FIGURE 5

Case Study: Delay in Retinal Detachment Leading to Devastating Complications Surgery and Subsequent Silicone Oil Removal Leading to Complications

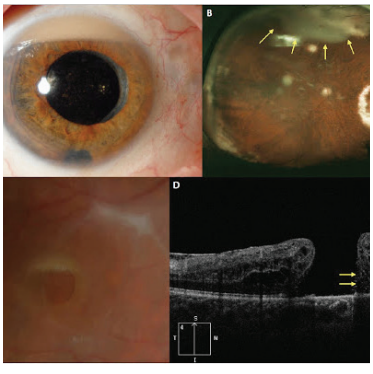
Budi is an Indonesian factory worker in his 40s who has been experiencing floaters and flashes in his vision over the last few years. One day, Budi notices a dark shadow coming across the side of the vision of his right eye. He goes to the nearest Puskesmas to his hometown, where a basic eye examination is performed. He is given a memo and referral to a Class C hospital further away to qualify for BPJS reimbursement.

At his appointment a week later, a fundus examination is performed, which confirms that he has a partial retinal detachment in his right eye. But there are no retina specialists nor the necessary equipment in the Class C hospital to do anything more. Budi is given another referral to a Class A hospital in Jakarta. By the time Budi is seen in a Class A hospital 2 months later, he is found to have total retinal detachment and is blind in his right eye. Because he still has vision in his other eye, he is scheduled for 'early' retinal surgery 2 months later. Budi is representative of the over 2000 patients waiting to receive retinal surgery in one of Indonesia's Class A hospitals. Delayed diagnosis and delayed initial surgical intervention has led to permanent & irreversible vision loss for one of Budi's eyes.

The backlog for retinal surgery has further implications, reducing the provider's capacity to perform follow-up procedures for retinal surgery, such as silicone oil removal. This leads to other complications, such as secondary glaucoma and cataracts.

Total rhegmatogenous retinal detachment with severe proliferative vitreoretinopathy.

Source: ASRS image bank (Retrieved Sep 2019)



Silicone oil emulsification.

Source: Retina Today Sep 2015

Measures for Cost Reduction

Most of the solutions mentioned in the previous two sections—including new technologies and business models that facilitate health literacy and decentralised care—hold potential to reduce costs and thus alleviate burden on public healthcare systems. Governments across Asia should strongly consider investing in these solutions in order to ensure that a greater share of patients can benefit from preventative care or ophthalmology treatments when needed.

For new medical technologies and therapies, effective deployment of health technology assessment (HTA) can help governments ensure that they focus limited resources on high-impact solutions. HTAs help to rationalise policy decisions through the systematic evaluation of properties, effects and/or impacts of novel interventions[23]. HTA cost-effectiveness thresholds vary based on each country's individual circumstances, so some solutions may be more appropriate in some contexts than others.

Finally, public insurance programmes could consider at least partial reimbursement for indirect medical costs, such as travel and lost earnings, in order to provide end-to-end coverage for patients. In the case that this is not feasible due to budgetary pressures or administrative challenges, governments could undertake efforts to encourage growth in private healthcare insurance markets, which can help improve coverage while also alleviating burdens on public hospitals.

Conclusion

As this report shows, eye health innovation requires multi-stakeholder collaboration and a nuanced understanding of the patient journey. This became even more apparent when the COVID-19 pandemic gripped the world in the opening months of 2020, causing major disruptions to existing care pathways in ophthalmology.

As many sought to avoid interactions and delay non-urgent consultations or procedures, outpatient volumes in eye care clinics plummeted and follow up intervals between visits lengthened, resulting in adverse clinical outcomes and irreversible loss of sight for some patients[24]. At the same time, the pandemic may accelerate the adoption of new technologies and business models to enable remote ophthalmological care or prevent eye disease from happening in the first place.

This report presents several ideas for structuring those efforts. Drawing upon insights generated through clinic-based immersive observation and interviews at various healthcare institutions in Singapore, China, and Indonesia, it provides insights on key areas of opportunity and local nuances in these three countries. In particular, it will be essential for health systems to embrace new innovations. It is also critical that entrepreneurs and innovators work to localise their efforts to the specific needs of the markets they aim to serve.

Given the fast-changing nature of the epidemiological and cultural drivers of eye disease in Asia, however, further research will be needed to validate these insights and apply them more widely in the region. As such, the report is intended primarily as a catalyst for further research, innovation, and entrepreneurship to address the region's vast unmet needs in ophthalmology and eye care.

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Empowering Asia's Healthtech Innovators of Tomorrow

Modelled after the established Biodesign Programme at Stanford University, Singapore Biodesign is a capability development initiative that aims to train and nurture the next generation of healthtech innovators for Asia.

We are a dedicated talent development and knowledge resource for health technology innovation, riding on the robust biodesign methodology and our wide-ranging regional network to provide an appreciation of healthcare needs through observations from stakeholder perspectives.

MISSION

High-touch development of healthtech talent centered on needs-based approach and quality industry mentoring to accelerate health technology innovation and adoption for Asia's* unmet healthcare needs.

VISION

To be Asia's* leading healthtech talent development and knowledge partner for accelerating health technologies innovation towards commercialization and adoption.

*Asia refers to SG, China and ASEAN

SINGAPORE BIODESIGN

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HOST INSTITUTION:

Agency for Science, Technology and Research
SINGAPORE

JOINT PROGRAMME PARTNER:

STANFORD BYERS CENTER FOR BIODESIGN