MedTech R&D in Singapore

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Content

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The surge of digital technology adoption in daily human activities is also occurring in the Medical Technology (MedTech) field. With the appearance of digital technology has brought new innovation in MedTech, it can be applied to tackle major clinical problems and diseases. Digital technologies adopted in MedTech are ranging from internet of things (IoT), big data, and artificial intelligence (AI). These technologies establish a highly interconnected digital ecosystem, enabling real-time data collection, which could be processed by AI and deep learning systems to understand healthcare trends, model risk, and prediction outcomes.

APAC's Medical Technology (MedTech) industry is projected to reach SGD 212.59 billion in 2022.[1] Despite the economic recession caused by Covid-19, the MedTech industry in Singapore continues to grow[2]. MedTech in Singapore represents an important sector of the economy, sustaining more than 9,000 jobs. It currently hosts more than 60 multinational MedTech manufacturing and R&D companies with 50 regional headquarters and over 250 MedTech start-ups and small-medium enterprises[3].

At present, Asia represents a significant emerging market for MedTech companies and is predicted to outstrip the European demand for MedTech in the coming decade[4]. This gives them the chance to innovate and create cost-effective solutions to meet the region's healthcare needs. Singapore is currently leading Asia's MedTech research and development. It accounted for SGD 105 million of HealthTech funding which is 24% of total investment across the continent (except China and India)[5]. Today, 60 global MedTech firms, including Biosensors, Becton Dickinson, Alcon, and Hill-Rom, and even some local start-ups, including HealthSTATS and Veredus Laboratories, have their R&D centers in Singapore[6].

Infrastructure

Traditionally, the MedTech industry is not easy to enter due to high barriers of entry and longer incubation phases. In Singapore's instance, owing to many IT, electronics, and software companies, entry barriers to MedTech are lowered. According to J. Teo, director for healthcare and biomedical at Enterprise Singapore,

"These provide early-stage incubation support and investments in MedTech start-ups and enables them to fast-track the development and commercialisation of technologies"[7].

The National University Health System's Centre for Innovation in Healthcare allows them to test their products in live ward settings before final product validation. Likewise, it offers services like health technology assessment, business evaluation, and access to networks and capital[8].

One of the key stakeholders, the Institute of High Performance Computing (IHPC) (a Research Institute under A*STAR), has formed the Health and Medical Technology Innovation Technology Area (ITA) group to leverage the cross-disciplinary potential of multiple departments and set up the following R&D priorities:

- Digital healthcare with a focus on ophthalmology
- Health-tech for wellness and pre-disease screening
- Geriatric care
- Modeling and simulation for production and design of medical devices.

The following trends and conditions are important to consider on the local MedTech R&D scene:

- AI and mobile technology now lead the way in medical innovation. The former allows companies to analyse medical data to develop better diagnostics services, and the latter played a critical role in tracing Covid-19 infections in the country. MedTech companies in Singapore are increasingly leveraging smart devices to provide medical information and encourage health monitoring. By doing this, they can lower the cost of developing, delivering, and scaling their health solutions.

- Opportunities in Singapore's MedTech R&D environment are strongly supported by the government's initiatives to help channel foreign investors' much-needed financial resources. The local government also controls investment vessels such as the country's sovereign wealth fund, the GIC, which works together with venture capitalists such as Sequoia and Temasek to invest in startups

domestically and internationally. Government research agencies also host collaborations with the private sector to organise accelerators and incubators, acting as a matchmaking center for MedTech players and investors.

- Singapore is still heavily dependent on the imports of medical supplies, and recent drops in local STEM graduates further compounds regional talent gaps.

1. Current Innovation and R&D Strategy

MedTech demands are reflected in the current Singapore healthcare ecosystem. Many MedTech companies are leveraging devices that people use daily to provide medical information and encourage health monitoring. This approach potentially lowers the cost of developing, delivering, and scaling Singaporean health solutions by leveraging existing products and technologies. Many MedTech companies in Singapore use collaborative design, public-private collaboration, and investor fundraising in establishing tech-based healthcare[9]. Collaborative design enables MedTech and startups to work together to tackle health issues. The public-private collaboration brings together government, academic expertise, startups, and cooperation under Singapore's MedTech industry.

Singapore constantly focuses on healthcare R&D by putting the healthcare development roadmap as part of its yearly Research Innovation Enterprise (REI) plan. In 2021 Singapore R&D in healthcare is focusing on Covid-19 response and has developed a technology called The Fortitude Kit. It is a Covid-19 diagnostic test developed by Singapore Biomedical Science (BMS) and co-developed by A*Start and Tan Tock Seng Hospital. The Fortitude Kit has since been deployed to over 40 countries[10].

The popularity of AI and technology implemented in healthcare has increased during the Covid-19 pandemic. SingHealth institutions and teams rallied together to design, build, and deploy smart solutions to address challenges patients and healthcare staff face during the pandemic. For example, AI is used in Singapore as a predictive tool to determine the severity of a patient's pneumonia based on chest X-ray images. With social distancing and a call for lesser in-person contact, Singa-
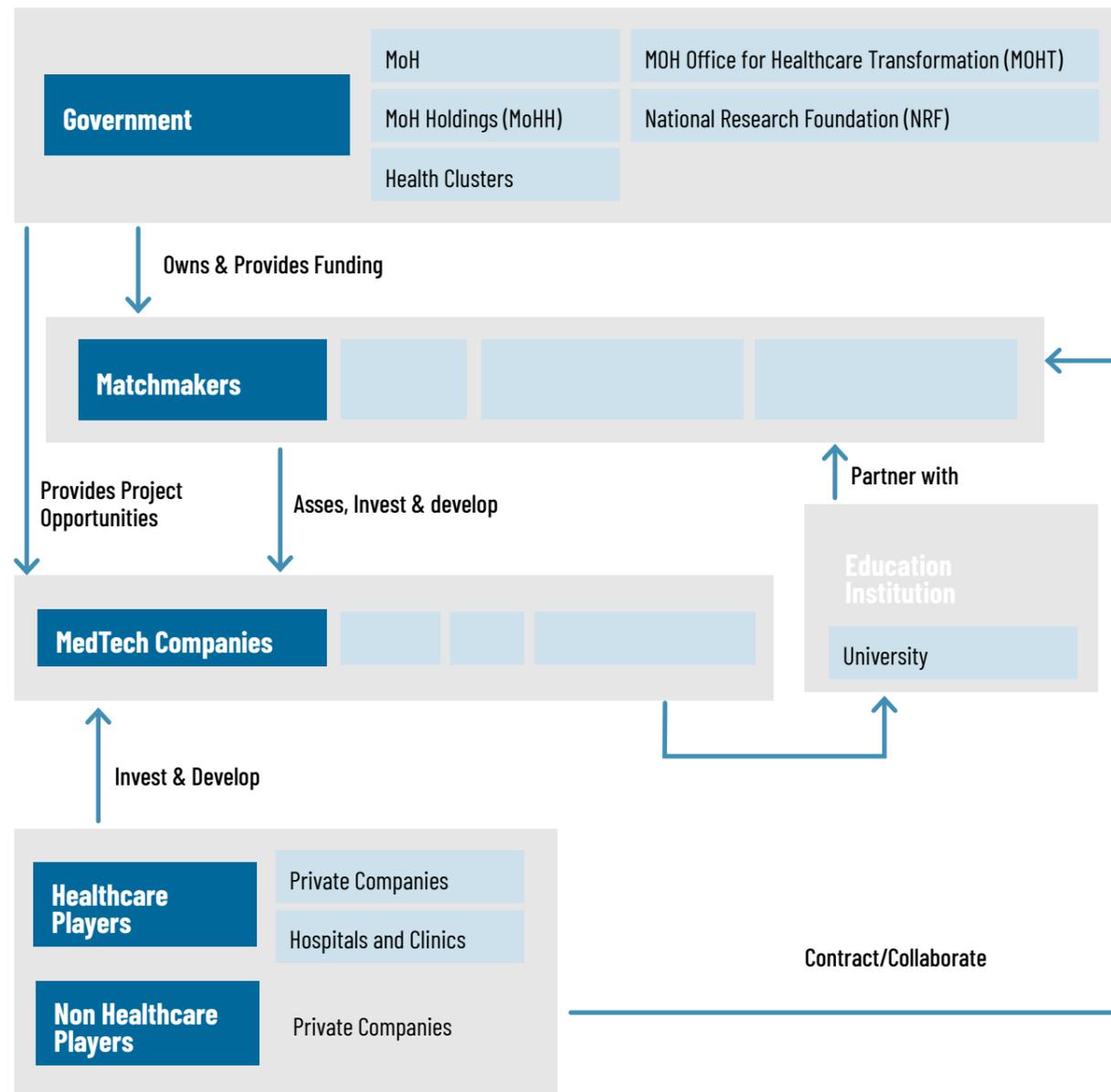
pore ensures that front liners and healthcare staff are safe by relying on robots instead for such interactions. There are two types of robots, SwabBot and Temi. SwabBot is a made-in-Singapore robot that can automatically complete a nasal swab test in just 20 seconds, and Temi is a remote-controlled robot used to deliver medications and assist social workers in tele-counseling with patients[11].

Singapore R&D in the healthcare sector is appraised to be modern. This is because Singapore has at least a four-year roadmap for healthcare development. For the 2025 strategy, Singapore will focus on transforming and protecting health, maximising economic value, and advancing human potential.

Singapore is transforming its health system to deliver better health and healthcare outcomes for Singaporeans by PREPARE and PRECISE programs. Prepare stands for Programme for Research in Epidemic Preparedness And REsponse; this program will strengthen diagnostics, therapeutics, and vaccine development platforms. PRECIsion Health Research, SingaporE (PRECISE) is the central entity coordinating whole-of-government efforts to implement Singapore's national PM research strategy. PRECISE aims to integrate large-scale genomic, phenotypic, lifestyle, and clinical data to understand how these factors contribute to health and disease in our population[12].

The following strategies are maximising economic value and advancing human potential. Singapore is planning to monetise the MedTech industry and invest more in human development to reinforce the growth of MedTech in Singapore.

2. MedTech R&D Ecosystem Mapping

Government

MoH	MOH Office for Healthcare Transformation (MOHT)
MoH Holdings (MoHH)	National Research Foundation (NRF)
Health Clusters	

Owns & Provides Funding

Matchmakers

Provides Project Opportunities

Asses, Invest & develop

Partner with

Education Institution

University

MedTech Companies

Invest & Develop

Healthcare Players

Private Companies

Hospitals and Clinics

Non Healthcare Players

Private Companies

Contract/Collaborate

Key Stakeholders of MedTech R&D Ecosystem in Singapore

Government

- **Ministry of Health (MOH)**

  The main governmental institution managing the public healthcare system. Provides subsidised medical services, safety nets for disadvantaged populations, also licences and regulates all healthcare establishments.

- **MOH Holdings (MOHH)**

  A holding company of Singapore's public healthcare clusters – National University Health System, National Healthcare Group, and Singapore Health Services. On a mission to "enhance public healthcare sector performance by unlocking synergies and economies of scale."

- **Health Clusters**

  The three clusters were created to offer a fuller range of services for all kinds of care. They are meant to meet the upcoming healthcare challenges, optimise use of resources and efficiency and provide more professional opportunities for public medical employees:

  1. **Central region:** National Healthcare Group (NHG) and the Alexandra Health System;
  2. **Eastern region:** (SingHealth) and the Eastern Health Alliance (EHA);
  3. **Western region:** National University Health System (NUHS) and Jurong Health Services (JurongHealth).
  4. **Enterprise Singapore** is the government agency work with committed companies to build capabilities, innovate and internationalise. Enterprise Singapore also support the growth of Singapore as a hub for global trading and startups.

- **Office for Healthcare Transformation (MOH)**

  An agile unit with the mandate to take an experimental and evidence based approach to redesigning healthcare in Singapore

- **National Research Foundation (NRF)**

  Sets the national direction for research and development (R&D) by developing policies, plans and strategies for research, innovation and enterprise. It also funds strategic initiatives and builds up R& D capabilities by nurturing research talent.

Healthcare Players

- **Private Companies**

  Pharmaceutical: Research, development and manufacture of medical products, treatments and devices, consumer health

  MedTech and BioTech: Home monitoring solutions, wellness solutions, imaging analysis, and more

- **Hospitals and Clinics**

  Public and private: 80% is provided by public clinics and hospitals, 20% by private ones

Non-Healthcare Players

- **Private Companies**

  Technology: Providing a technical base for MedTech and other healthcare companies

  Nutrition: Consultancy, consumer goods manufacturing, health supplements

Matchmakers

- **Research & Consulting**

  Innovation consulting firms: market studies, market access, innovation strategy, product launch, strategic foresight, fundraising, business development, cluster study etc.

  A*STAR and other research agencies: pioneering research, developing talent, bridging the gap between academia and industry

- **Singapore Economic Development Board (EDB)**

  Government agency responsible for sustainable economic growth, investing in high growth tech sectors, including healthcare. Provides information, facilitates partnerships, helps to access government incentives for their investments

- **Enterprise Singapore**
  A the government agency work with committed companies to build capabilities, innovate and internationalise. Enterprise Singapore also support the growth of Singapore as a hub for global trading and startups

  MedTech Actuator: accelerator providing mentorship, investment, partnership and networking

  Technology Centre of Accuron MedTech: incubator for deep-tech healthcare startups offering mentorship and investment

  Catalyst: innovation hub for MedTech startups, coworking space providing networking, collaboration, and training

  SG Innovate – launching, proving, scaling deep-tech products.

Medtech Companies

- **Startups**

- **Small and Medium Enterprises (SME)**

- **Multinational corporations**

  Startups: young small-sized companies delivering innovative products and solutions to local and international market

  SME: major producers of medical products and solutions, employers of thousands of employees.

  Multinationals (Philips, Siemens, Novartis, GE and others): most are long established in Singapore, attract world-class talent to the country, have industrial manufacturing units.

Research and Matchmaking

Investments towards MedTech can come from non-healthcare players, especially companies providing digital services and looking to expand their product portfolio. Halodoc, a MedTech startup, received investments from Singtel, a leading telecommunications company and ride-hailing player Gojek. Both companies have since included pharmaceutical deliveries into their service offerings, with Gojek becoming Halodoc's sole delivery partner. FMCG companies with a presence in the nutrition market, such as Danone, are partnering with MedTech firms like ObvioHealth to track in real-time whether a baby's crying is triggered by hunger or other factors. In 2019, MedTech financing in the Southeast Asian region totaled SGD 300 million, of which 54% of went into Singaporean firms[13].

Singapore's research and innovation ecosystem comprises many ministries, including the Ministry of Health, R&D funding providers like the National Medical Research Council, and R&D performers like hospitals, universities, and research institutes. Generally, global pharma and medical companies approach innovation through in-house R&D activities, open innovation teams, and corporate investment teams actively pour capital and expertise in the region.

With numerous businesses across industries competing for a stake in MedTech opportunities, "matchmaker" agencies are in demand to connect them with the right partners. Before exploring further opportunities, businesses may choose to engage independent agencies before committing to an investment. These engagements can be short-term or for lower-risk opportunities as an entrant to the industry.

Catalyst companies like Padang and Co. deliver strategic partnership opportunities for global companies looking to collaborate with technology firms. While Galen Growth, one of Singapore's most prominent matchmakers for health technology, focuses on clients from investors, pharma companies, and insurers. Alternatively, businesses can partner with reputable names or sponsor initiatives to discover investment opportunities for the long term[14].

Public and private institutions often organise events for startups, such as innovation or incubation hubs. In 2019, Enterprise Singapore and the country's monetary authority launched Deal Fridays to connect startups across industries with potential investors, intended to facilitate SGD 1 billion in capital investments. Their other major partnership was with Bluechilli to create a MedTech-centered accelerator in the quest to build accessible and affordable healthcare solutions. Other government agencies, including Singapore's sovereign wealth fund, the GIC, actively invest in startups in and outside of Singapore. While A*STAR provides MedTech companies access to research expertise, venture co-creation, accelerators, and portfolio management[15].

Below is a list of 9 successful R&D developments which have been fostered in this ecosystem:

Project	Institutions	Description
Selena+ AI algorithms for eye disease detection	SNEC, SERI, National University of Singapore's School of Computing	Diabetic Macular Edema detection, glaucoma detection from optical coherence tomography scans, papilledema detection from fundus photos, myopic macular degeneration from fundus photos, identification of optic nerve abnormality with high accuracy.
microRNA technology[16]	miRXES	Technology for clinical purposes and is working on launching blood tests for gastric, breast, and lung cancers and a pan-cancer screening test.
Thermo Fischer Scientific[17]	A*STAR	First cloud-enabled instrument for improving lab productivity: multiple systems on a single platform to allow users to remotely monitor their experimental runs and results in real-time on mobile devices, as well as to perform preliminary analyses with a toolkit at their disposal.
Wearable device for arrhythmias	Biorithm	A wearable device that detects arrhythmias in real-time through sensing ECG pulse.
Genomic sequence analysis to research institutes	Visuho	Singapore-based healthcare technology company that offers genomic sequence analysis to research institutes, health screening clinics, hospitals, and the pharmaceutical industry.
Microfluidic devices	AIM Biotech	Microfluidic devices for research applications, beginning with 3D cell culture systems.
Microbial detection system	Biopsin	Microbial detection system for testing food, beverages, water, consumer goods, and pharmaceutical products.
Parameter sensors	Aerosens	Parameter sensors to measure differential pressure, temperature, relative humidity, carbon dioxide, carbon monoxide, and air quality.
Technology platform based on genetic engineering	Medisix Therapeutics	Technology platform based on genetic engineering to generate T cells for treatment of leukemias and lymphomas.

MedTech Startups

As of 2018, there are well over 170 MedTech companies in Singapore, up from 105 in 2015 and a mere 45 in 2012. MedTech companies serve healthcare providers, pharma companies, and at times, patients. MedTech companies focus on the consumerisation or digitisation of healthcare technologies, making them accessible to the public.

The growth in MedTech can be attributed to several factors, such as rising incomes, underdevelopment of healthcare infrastructures, and a graying population. Singapore is also a health technology hub for companies seeking to raise capital within the ASEAN region. The estimated market value stands at SGD 139 million, a stark gap with neighboring countries like Indonesia at SGD 19 million.

These companies are presented across categories such as wellness (19%), medical diagnostics (14%), health management solutions (13%), health services search (10%), remote monitoring (9%), patient solutions (8%), and others (27%)[18].

Universities

Institutions of higher education also have a hand in supporting the role of matchmakers within the ecosystem. Universities partner with agencies like A*STAR to cultivate budding entrepreneurs interested in MedTech by providing them with training, mentoring, and opportunities to meet with investors with the potential to seek funding in the future.

These partnerships are also developed between the campuses, such as NUS, NTU, and SUT, which created the JUMPstart program to accelerate MedTech innovation[19].

Government

We have seen the critical role the Singapore government plays in encouraging entrepreneurial and innovative ventures. Yet, it is also important to note that the government actively partners with MedTech companies. Singapore's public healthcare system has been accelerating its digital transformation efforts to deliver on its commitment towards patient-centricity and first-class healthcare services. We see companies like Holmusk using machine learning to improve care for patients with coronary artery disease at the National Heart Centre Singapore[20].

MOH is opening up opportunities for the MedTech space by funding research institutions such as A*STAR to support healthcare-related initiatives that tap into the MedTech space. At the same time, health clusters are also creating an entry-point strategy for MedTech companies to bid for large-scale tenders on programs and partnerships to digitise the country's healthcare environment.

In 2019, the healthcare clusters supported MedTech hub, co-curated and operated by Padang & Co, aimed at accelerating and improving the development of preventative and curative products called Catalyst. So far, ten startups have made Catalyst their home, giving them access to matchmaking opportunities with healthcare practitioners and companies while also being mentored throughout the process[21].

Established Companies

Over the past years, Singapore has seen an increased interest from established industry players seeking to tap into the country's growing MedTech space. There are more than 100 global pharma and medical devices manufacturers in Singapore. For many players, diagnostics, early detection for diseases, access and affordability, awareness, and treatment adherence are vital points driving partnerships with digital providers.

Novartis, for example, works with Healint to target patients with migraines by providing them an app to track headaches and migraine attacks triggered by anxiety and depression. Zuellig Pharma, one of the world's largest distribution partners for big pharma companies, has also invested in Docquity, a social media platform for healthcare professionals that enables clinical discussions and the continuation of medical education (CME) activities[22].

At present, more than 200 MedTech small- and medium-sized enterprises operate in Singapore, some of them are:

- **Histoindex:** developing new diagnostics for fibrosis and cancer.

- **MiRxes:** using microRNA technology for clinical purposes, such as blood tests for gastric, breast and lung cancers, and a pan-cancer screening test.

- **Curiox Biosystems:** developing bioinstrumentation solutions for cell analysis and therapy for the pharmaceutical and biotech industries.

The market is very attractive for multinational companies: the US MedTech company Thermo Fisher Scientific established a research partnership with Singapore to develop new cloud-based solutions. Or BD, a global MedTech company with headquarter in Singapore that opened an innovation center to develop new technologies[23].

3. SWOT Analysis on MedTech R&D for Foreign Research Institutions

The following SWOT analysis is done and summarised in the following matrix to help companies assess opportunities to enter Singapore's MedTech industry.

STRENGTH	WEAKNESS
• Supportive ecosystem • Two universities in world top 20 • Sandbox environment for telemedicine and ethics	• Decreasing local STEM graduates • Low supplier power/Reliance on imported medical equipments and pharmaceutical • Lack of balance between clinical practice and R&D Activities
OPPORTUNITY	THREAT
• Singapore as a stepping stone to ASEAN markets • Data analytics and National AI strategy	• Privacy • Cyber security risks preventing citizen's sharing in personal data usage

Strength

Supportive Ecosystem

The ease of doing business in Singapore is complemented with a support ecosystem that MedTech companies can tap into. This support ecosystem has been part of Singapore's plan to encourage multinational corporations to develop innovative solutions. Singapore has two universities ranked in the Top 20 globally by QS and a cluster of research institutes under A*STAR, a government statutory body established by the Ministry of Trade and Industries to enhance Singapore's R&D activities. These entities can assist MedTech companies by supplying them with quality researchers and access to top facilities.[24]

In 2020, the Licensing Experimentation and Adaptation Programme by the Ministry of Health provided a sandbox environment tailored specifically for the healthcare market. The program was accompanied by supporting guidelines on telemedicine and ethics[25].

Weakness

Decreasing Number of Local STEM Graduates

If more tech companies choose to enter the Singaporean ecosystem, the number of STEM-related jobs will inevitably increase. Consistent with a Randstad survey, 55% of respondents stated their employers are recruiting for STEM positions. However, a study from Singapore's Ministry of Manpower shows that the number of local STEM graduates has decreased over the last ten years.[26] This may force Singaporean companies to hire foreign professionals instead of local employees due to a shrinking local talent pool.

Hiring highly skilled foreign workers would also incur higher costs as the companies need to sponsor them with an Employment Pass (EP). The government also launched TechPass in early 2021 to invite foreign tech-skilled workers to Singapore and has since approved 90 foreign workers. To do so, not only must companies acquire the approval of MOM (Ministry of Manpower), they are also obligated to provide a salary of at least SGD 4,500 per month for each foreign worker they sponsor[27].

Low Supplier Power

While Singapore is accustomed to relying on imported medical equipment and pharmaceuticals, given its relatively small population (5.8 million in 2021), it has tight regulations around consumer protection. International suppliers are competing fiercely for market share, considering relatively few buyers are available. This, therefore, forces entrants to either sell below the market rate and disrupt the industry or develop superior (premium-quality products) to justify an above-average price[28].

Lack of Balance Between Clinical Practice and R&D Activities

Doctors may find it challenging to balance clinical responsibilities at hospitals and R&D activities in research institutions within the Singaporean healthcare system due to their demanding work hours[29]. Doctors are currently working on average 80 hours a week at their clinical practice, which leaves little to no time in assisting research institutions in conducting R&D activities[30]. This slows down the MedTech innovation process. According to Dr. Yau Teng Yan, Chief Medical Officer at Holmusk, a space such as Catalyst can reduce the distance between clinical practitioners and the MedTech industry. Catalyst was created as a coworking innovation space that connects MedTech and Health Tech startups and clinical innovators with the mission to convert innovation into products and services for people's health [31].

An alternative solution is to mandate hospitals to allow doctors to assist institutions with clinical trials or prototype evaluations. This has been done at the KK Women's and Children's Hospital in collaboration with Singhealth[32]. Another solution, as suggested by Ms. Pang Sze Yunn at Philips ASEAN Pacific, is to have private companies such as Philips collaborate with doctors, employed both in the public and private sector, in their personal capacity, since they are permitted to work on hospital grounds with the company for specific projects or products[33].

Opportunities

Singapore as a Stepping Stone to ASEAN markets

It is common for foreign investors to use Singapore as a base to enter ASEAN's rapidly growing healthcare markets. The country's proximity to other members of the bloc and its innovative climate and ease of doing business are some of the primary reasons why, for instance, Siemens and Medtronics have chosen Singapore as the location for their regional headquarters[34].

The Singaporean government is also funding various research institutions geared at R&D in the pharmaceuticals and genomic fields. The ASEAN secretariat has pledged some SGD 19 billion for research and innovation for the 2016-2020 period, including SGD13.5 billion for science and technology[35]. In RIE 2025, SGD 25 billion is allocated for the research landscape, focusing on human health and potential. Moreover, local institutes are open to partnerships with Singapore-listed entities within the private sector. They can provide expertise and additional human resources to conduct basic services (i.e., genomic sequencing and clinical testing) on top of cutting-edge research. Here is a list of pharmaceutical and genomic research institutes in Singapore.

These factors put Singapore as a top choice when expanding to ASEAN markets. According to Singapore's Economic Development Board, 46% of regional headquarters of MNCs in Southeast Asia are based out of Singapore[36].

Data analytics and National AI strategy

By 2022, the global demand for mobile health solutions is projected to grow from SGD 28.59 billion in 2017 to SGD 122.22 billion. The pandemic has provided Singapore with an opportunity to enhance its existing healthcare workflow and broaden the health-tech field by developing innovative technologies to provide better access and treatment to people. A prime example of this is the TraceTogether App created by Singapore's GovTech. The app uses Bluetooth technology and QR codes to conduct contact tracing. More than 4.2 million residents are currently using it. Another example is HealthCerts, a new system for issuing digital Covid-19 test results.

Furthermore, AI is showing increasing signs of success in the health industry. According to Deloitte, AI has become a significant component in MedTech as current solutions gradually depend on data. In 2019, global investment in healthcare AI companies totaled nearly SGD 1.6 billion. AI is used in MedTech for descriptive and predictive analytics of patients' medical needs. An example is KroniKare, a Singaporean startup that uses an AI-enabled scanning system to provide a near-instant, non-invasive assessment of chronic wounds. The AI system in the device analyses the wound and compares it to 15 years of chronic wound data. It then produces an automated report that healthcare providers will use to determine the best course of action[37].

Singapore has also created a national program that in part aims to embed AI in chronic disease prevention.

- **Personalised risk scores for chronic disease:** The program leverages AI to create a customised risk score. The score is generated through analysing clinical records, medical images, lifestyle behaviors, and genomic data.

- **Clinical decision support for primary care doctors:** With the provision of a personalised risk score, primary care doctors can use available data points in clinical decision-making and implement relevant monitoring systems for patients. Primary care doctors can further assist patients in taking practical preventive steps and receiving earlier and more personalised treatments from medical professionals.

- **Personalised management of chronic diseases:** AI can also support primary care doctors and care teams in developing personalised care plans that consider a patient's risk profile. As each care team may look after many patients, AI can monitor patients' progress and alert care teams to patients whose progress shows causes for concerns so that timely action can be taken. Furthermore, patients may use AI to monitor their wellbeing and receive regular reminders to eat well, get more exercise, take their medications, and schedule checkups[38].

Threats

Privacy

Data privacy laws took effect with the Protection of Personal Data Act (PDPA) legislation in 2012. However, there are still gaps in mandating the use of personal data. A survey conducted by Oliver Wyman states that while 91% of Singaporeans are willing to share personal health information, only 65% are comfortable sharing their health data for public monitoring. At the same time, the survey claims that 30% of Singaporeans do not trust the existing digital data privacy and security regime[39]. Understanding this, companies looking to use personal data in their products must proceed with caution.

The integration of technology with healthcare raises the question of how new developments can invade people's privacy. One example is digital phenotyping that allows smartphone and wearable signals to measure cognition, mood, and behavior. This up-and-coming method was created as a passive assessment technique for mental illness diagnosis and treatment. The technique will involve processing vast quantities of individual data and possibly developing new types of health and risk assessment data.

Since current regulatory mechanisms still not explicitly extend to digital phenotyping, personal data privacy boundaries may be infringed. Hence, particular concerns about data security and how private medical data are handled are rising.[40] Some cases of unwarranted access to patient data and the risk of public disclosure of medical data led to the creation of the NGO Big Brother Watch[41].

4. Appendix A: Key Players of Singaporean Healthcare Industry

Company	Industry (Genomics/ MedTech/ Others)	R&D Focus
Cell ID Cell ID researches, manufactures, markets, and distributes point-of-care devices for DNA/ RNA/Protein based diagnostics. Cell id has created a near-field Point-Of-Care (nf-POC) HbA1c test kit with its unique integrated product test methods and manufacturing technologies. An integrated Printed Disposable Integrated PCR POC device which incorporates Cell id printing features including printed heater, printed microfluidics, printed bio-sensors, together with their proprietary assembly methods. It has also developed HIV and hCG testing kits.	MedTech	Internal Product R&D
Biorithm Wearable device that detects arrhythmias in real-time through sensing ECG pulse.	MedTech	R&D Partnership with NUHS, JumpStart, Hello Tomorrow Singapore, and NTU
Nanoprint Nanoimprint is a provider of microfluidics, biomedical, and MEMS systems through nanoimprinting. The company offers products such as photo-masks, silicon mold with photoresist patterns, silicon wafers and SOI wafers, microfluidic chips (polymer, glass, metal), high precision pressure pump for microfluidic control, auto medium exchanger for long-term cell culture, and special bio-compatible filters. It provides photo-masks fabrication (laser writing and E-beam writing), photo-masks design and revision, photo-resist mold (single layer or multi-layer) fabrication on silicon, silicon wafers and SOI wafers supplying, microfluidic chip (polymer, glass, metal) design and fabrication, OEM instrumentation for optical observation, detection and imaging processing, OEM instrumentation for wet etching, and material characterisation services. It has partnered with the National University of Singapore, Nanyang Technological University, and Singapore University of Technology and Design.	MedTech	Internal Product R&D

MiRXES Arks provide a non-invasive miRNA detection test. The company offers its blood-based test for the detection of early stages of cancer. The test detects cell-free miRNAs secreted by tumor cells in the blood.MiRXES is developing miRNA based research tools and diagnostics. The company's core technology is a highly specific RT-PCR primer that imposes a conformational restriction on miRNA for efficient binding to mature, but not precursor miRNAs, coupled with optimised RT-PCR reagents. These primers confer high specificity, sensitivity and enhanced signal-to-noise ratio in amplification reactions. The company manufactures miRNA detection and quantification kits for research and is developing miRNA-based liquid biopsy kits for gastric cancer, lung cancer, and breast cancer detection. The company was spun-off from the Bioprocessing Technology Institute of the Agency of Science Technology And Research (A*STAR) and is supported by Exploit Technologies and the National University of Singapore.	MedTech	Internal Productct's R&D
Proteona Proteona provides single cell proteogenomics based therapeutics. The company is offering its flagship ESCAPE Technology for enhanced single cell analysis with protein expression (ESCAPE) platform. The platform represents a suite of technologies developed by the company using DNA barcoded antibodies.	MedTech	R&D Partnership with A*Star, NUS, Singapore-MUT Alliance for Research and Technology (SMART), AI Singapore, REEROTS, LifeTime, EitHealth
Vela Diagnostics Vela Diagnostics develops and markets integrated molecular diagnostics solutions. Its Sentosa line of products are end-to-end automated PCR solutions and thermal cyclers. In addition, it also has a range of PCR kits for viral and bacterial diseases, and cancers, including leukemia.	MedTech	Internal Product's R&D
Naglenetics Nalagenetics has developed genetic tests kits for precision medicine. The company offers a range of genetic tests and assays. The genetic tests are used for analysing the drug reactions along with the information from information management systems. The company has also developed a clinical decision support system which uses the data and provides clinical recommendations. The information enables doctors to provide prescriptions or treatments. The company also offers the patients an app for information on medication side effects.	MedTech	R&D Partnership with Genome Institute of Singapore
Veredus Labrotaries VereFoodborne makes a nucleic acid-based, Lab-On-Chip (LOC) device which combines multiplex PCR and microarray hybridisation to detect, differentiate and identify multiple foodborne pathogens in one test.	MedTech	Internal Product's R&D
Data4Life data4life provides software solutions to researchers to access relevant clinical data and analyse it for scientific purposes. It helps them improve patients' health and prevent, detect, and treat diseases effectively.	MedTech	Internal Product's R&D

Macrogen Macrogen has been implementing various activities in genetically engineered mouse (GEM), disease and new medicine assessment using GEM, the development of molecular diagnosis kits, target treatment research, new medicine research, and gene treatment research using stem cells and induced pluripotent stem cells for the purpose of realising and implementing precision medicine. It has acquired more than 50 technologies, including the CRISPR-Cas9 portfolio of the Broad Institute.	MedTech	Internal Product's R&D

Endnotes

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Singapore and the Netherlands have strong economic ties and collaborate closely in the fields of life sciences and health, digitalisation, water, circular economy and agriculture & food. This article/report will give insight in the strategy, developments and opportunities for collaboration in life sciences and health, focusing on medtech and digital health/ biotech. The report is commissioned by the Netherlands Innovation Network (NIN). NIN is part of the Netherlands Embassy in Singapore and supports R&D partnerships. By working closely together with government, leading research institutes and companies, including start-ups and scaleups, their aim is to build and expand collaborations. TTo connect with the Netherlands Innovation Network at the Netherlands Embassy in Singapore please reach out via e-mail sin-ia@minbuza.nl.

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