Ministry of Foreign Affairs

Healthcare and R&D Landscape in Singapore

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Content

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1. Healthcare System in Singapore

Singapore is known for its highly developed market economy, bolstered by a strategic geographical location in maritime Southeast Asia. This city-state is also ranked 2nd globally by Bloomberg's Healthcare Efficiency Index, just behind Hong Kong[1]. Singapore's success in healthcare is attributable to a set of measures formulated and public policies refined over the past decades.

When optimising healthcare for its people, the nation also acknowledges the budgetary constraints faced when ensuring affordability and availability of medical supplies and professionals. There is also a need to ration demands and protect sustainability in healthcare resources. The Singapore government considers four avenues to balance these two goals: organisational, fiscal, informational, and regulatory[2].

One strategy example in 2017 aimed to bring together common alignment across these avenues. The government introduced a strategy called the "3 Beyonds" to ensure that healthcare remains high quality and affordable in the future. It includes the following focus points:

1. **Beyond healthcare to health:** focusing on prevention of disease, including healthier lifestyle choices;

2. **Beyond hospital to community:** letting patients receive appropriate care in the community or at home so they can stay well and avoid frequent hospital admissions;

3. **Beyond quality to value:** increasing quality of care while ensuring value for money and introducing fee benchmarks[3].

Currently, Singapore's healthcare system is divided into 80% public and 20% private. The public healthcare services are owned by the government of Singapore, for instance the public hospitals offer inpatient, outpatient, and emergency services. These hospitals are clustered into three groups: National University Health System (NUHS), National Healthcare Group (NHG), and SingHealth. There are two leading private providers for hospital care - Parkway Pantai and Raffles Medical Group. Meanwhile, for the private sector it is supported through a network of polyclinics and private practices.

1.1. Current Challenges and Priorities

The country's healthcare system faces multiple challenges that threaten its quality and affordability. The table below summarises these challenges and priorities chosen by the government as remedial measures.

Challenges

Aging Population

The population segment above the age of 65 will increase by threefold in 2030. The elderly population may spend nearly twice as many days in the hospitals as those below 65, rising per capita spending for elderly healthcare[4]. According to Marsh McLennan, a risk consulting company, the amount that an individual elderly citizen would have to spend on healthcare would rise from SGD 10,866.01 in 2015 to SGD 49,619.59 by 2030[5].

Chronic Diseases

The five most common chronic diseases in Singapore are diabetes mellitus, hypertension, high cholesterol, stroke, and heart attack[8]. Obesity, cancer, and chronic respiratory disease are significant concerns as well.

Priorities

Strengthening the Sector

The Singaporean aging population is one of the focus areas in the government's healthcare masterplan 2012-2020. The action plan for successful ageing has more than 70 initiatives in 12 areas, which involves many stakeholders such as 10 Singapore's Agency for Integrated Care (AIC) for integrated care agencies, regional health systems (RHS) for integrated clusters health systems, and medical practitioners for integrated care services in Singapore[6].

In terms of the financing In the face of growing healthcare challenges and expenditures, the government seeks to support the healthcare sector through means other than its fiscal tools. The Ministry of Trade (MTI) has provided funds through Enterprise Singapore, a government agency, to local startups and SMEs with promising solutions in various fields, including healthcare.

This is exemplified in this year's Healthcare Open Innovation Challenge, where startups with potential solutions were invited to co-develop a product with Singapore's established companies and medical entities. The Ministry of Education (MOE) also provides funds and platforms to researchers at Singapore's autonomous universities and research institutes to develop new treatments and medical devices[7].

Priorities Set in 2021

In 2021, the Ministry of Health (MOH) declared its plan to improve people's health and quality of life, focusing on delivering person-centered care and building a proactive and inclusive care system. The strategic priorities chosen are as follows:
- Fostering Healthier Lifestyles for Different Population Segments
- Strengthening Efforts to Support the Mental Wellness of our Population
- Meeting the Needs of Seniors of Today and Tomorrow.[9]

Shortage of Manpower in Healthcare

Singapore suffers from a global shortage of talent in healthcare, especially nurses. This is a critical issue, considering the aging population and inability to replace the missing workforce with machines. So far, the nursing profession has proved to be unattractive to Singaporeans because of low wages and irregular working hours.

Affordability

Despite attempts to reduce the cost of treatment, Singaporeans are still mandated to pay Out-Of-Pocket fees, including additional charges for emergency services. This mandate burdens lower-income citizens and can discourage them from seeking potentially life-saving medical attention. The issue is further exacerbated because Singapore has no minimum wage[12], and therefore, access to needed healthcare services is not guaranteed.

Staffing the Sector

The government is addressing this problem through more training in the sector, extending e-health services, and moving senior healthcare from hospitals to homes and communities[10].

Likewise, MOH now offers a benefits package for nurses, re-employs retired nurses and offers flexible working hours. The ministry also launched a scholarship to attract local and international students to study nursing for the future workforce in all healthcare fields.[11]

Reducing Inequalities

Hospitalisation, outpatient care, and long-term care are highly subsidized - up to 80% at all public hospitals.

In addition to insurance, MediSave funds are deducted monthly from every citizen's salary, providing means to cover unexpected medical expenses.

In 2020, ElderFund was launched to support the severely disabled with financial difficulties. A system of differentiated charges was also adopted, based on the patient's income and their family's ability to pay[13].

Healthcare Regulatory Policies

An important feature of Singapore's health system is the government's strict control over access to services. Policymakers rely on controlling the supply and demand of medical treatments, devices, and drugs to encourage patients and providers to be prudent and cost-conscious[14].

For example, Medishield covers only inpatient costs for entry-level hospital wards. If a patient chooses to admit to a better-classed ward, they receive fewer government subsidies. Similarly, with treatment costs being reimbursed by health insurance or saving plans, the opportunity for advanced tertiary care or diagnostic testing will be limited through lengthened waiting times. Nevertheless, patients can still choose to enter private hospitals and request specialist attention immediately. However, they will not receive subsidized prices[15].

Furthermore, there are restrictions on the use of Medisave and a cap on the maximum amount payable to providers from personal Medisave accounts. These measures are designed to reduce the misuse of public funds. MOH closely monitors the charging practices of hospitals and would issue alerts when anomalies or overtreatment is suspected[16].

In controlling medical supply, the Health Science Authority (HSA) ensures the safety and adequate provisions of devices and pharmaceutical drugs. It oversees the export and import of medical devices in Singapore by setting out standards and regulations. Pharmaceutical companies and medical device manufacturers must receive clearance from the HSA before launching a product in Singapore or importing it[17].

Healthcare Data and Information Policies

To utilize the full benefits of modern information technology, the Singaporean government encourages hospital groups to coordinate their financial, clinical, administrative, and diagnostic processes through integrated information systems called National Electronic Health Record Singapore (NEHR)[18]. The NEHR is managed by the Integrated Health Information Systems (IHiS), a Singapore health tech agency.

Since 2003, public hospitals are required to report the average overall charges to patients (which include fees for room, treatment, surgery, laboratory services, etc.) They are also mandated to collect data on the distribution of critical illness bills and bed occupancy rates. The collected data will then be published on MOH's website for public viewing[19].

In 2018 in Singapore, a significant cybersecurity incident known as SingHealth Data Breach served as a wake-up call to severe national healthcare data protection weaknesses. 1.5 million patients' data was accessed and copied by individuals posing as public agents. Investigation revealed multiple causes of the breach (which began in 2017): lack of employee training, poor system management, lack of resources, coding vulnerability, and more. This event served as a lesson to the government, which came up with multiple recommendations and measures to prevent reoccurrence[20].

Singapore's Artificial Intelligence (AI) strategy includes multiple vital projects, including healthcare, particularly around Chronic Disease Prediction and Management. They include:

- Personalised risk score for chronic diseases
- Clinical decision support for primary care doctors
- Personalised management of chronic diseases.

Other objectives under the national AI strategy involve clinical decision support for primary care doctors and empowering patients to manage their diseases better[21].

By 2022, it is expected to develop an analyser for diabetic retinopathy screening across the nation, by 2025 to develop a retina-based risk score for cardiovascular diseases, and by 2030 to collaborate with industry to co-develop novel AI models[22].

Organisational Healthcare Policies

A distinctive feature of Singapore's healthcare system is that the government has significant ownership of local hospitals, with public hospitals accounting for more than four-fifths of all hospital beds in the country.

In essence, the public ownership of private legal companies gives hospitals the autonomy required to operate in a competitive environment while ensuring that public interest is the primary objective being served as opposed to profit-oriented motives. It also provides the government with channels to receive market feedback and tools to monitor hospital behavior. The government can shape the behavior of hospitals without being subjected to cumbersome regulations or purchase negotiations, which would be necessary should these hospitals be solely private entities.
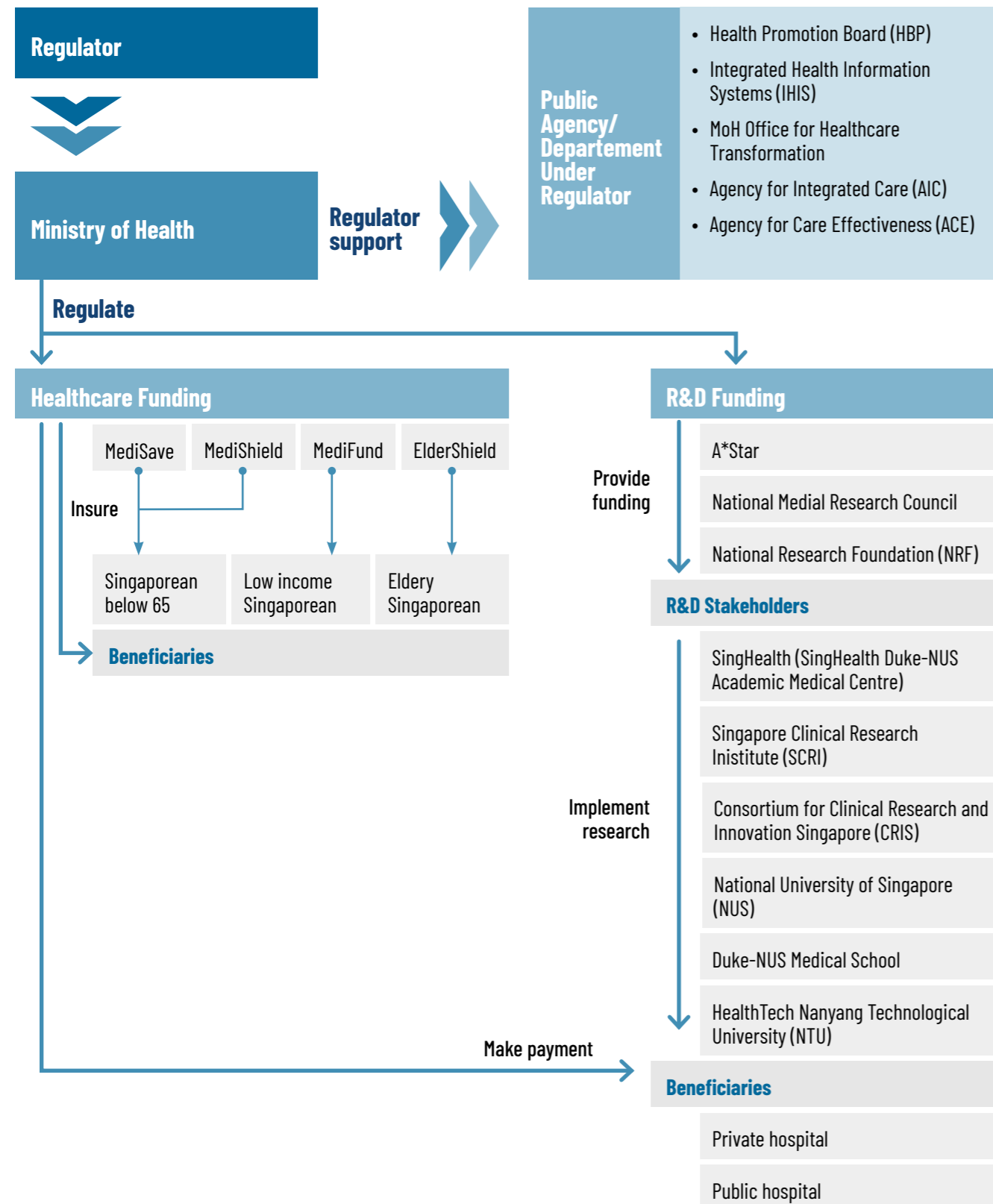
Fiscal Healthcare Policies

In Singapore, tax funds for healthcare consist of transfers to public hospitals to subsidize patient care costs and tax deductions for medical savings contributions. The government pays public hospitals based on a combination of cases (diagnosis-related clusters or DRGs) and block grants. It has a series of frameworks for fund distributions that can be found here. As of 2021, MOH has committed to subsidising at least 30% (and up to 80%) of hospitalisation bills for public hospitals. It also committed to ensuring that citizens from low-income households would only pay 30% of outpatient bills. They are also entitled to other subsidies (upwards of 40%) when receiving treatment at outpatient specialist clinics[23].

Data collection initiatives have also allowed MOH to develop an online calculator to help patients estimate the cost of treatment for a particular disease and determine the portion of the bill that Medisave and Medishield can finance. Such a tool allows citizens to make informed decisions about specific hospitals and ward categories, thereby reducing cases of overtreatment[24].

Healthcare Systems Ecosystem Map

Regulator

Ministry of Health

Regulator support

Public Agency/ Departement Under Regulator
- Health Promotion Board (HBP)
- Integrated Health Information Systems (IHIS)
- MoH Office for Healthcare Transformation
- Agency for Integrated Care (AIC)
- Agency for Care Effectiveness (ACE)

Regulate

Healthcare Funding

MediSave | MediShield | MediFund | ElderShield

Insure

Singaporean below 65 | Low income Singaporean | Eldery Singaporean

Beneficiaries

R&D Funding

Provide funding

A*Star

National Medial Research Council

National Research Foundation (NRF)

R&D Stakeholders

SingHealth (SingHealth Duke-NUS Academic Medical Centre)

Singapore Clinical Research Inistitute (SCRI)

Consortium for Clinical Research and Innovation Singapore (CRIS)

National University of Singapore (NUS)

Duke-NUS Medical School

HealthTech Nanyang Technological University (NTU)

Implement research

Make payment

Beneficiaries

Private hospital

Public hospital

Essential stakeholders in healthcare and R&D in Singapore

Public Agencies

- **Ministry of Health (MOH)**
  Manages the public healthcare system to ensure high quality and affordable basic medical services to Singapore residents. Licenses and regulates all healthcare establishments.

- **Health Promotion Board (HPB)**
  Acts for health promotion, disease prevention and patient education. Establishes, engages and supports local and international partnerships.

- **Integrated Health Information Systems (IHIS)**
  Technology agency for the public healthcare sector which digitises, connects, and analyses Singapore's health ecosystem.

- **MOH Office for Healthcare Transformation**
  A MOH unit which takes an experimental and evidence based approach to reshaping healthcare in Singapore.

- **Agency for Integrated Care (AIC)**
  Coordinates and supports efforts in integrating care to achieve the best care outcomes. Informs caregivers and seniors on staying active and aging well, supports and connects partners to strengthen their potential to provide quality care.

- **Agency for Care Effectiveness (ACE)**
  Improves patients outcomes and healthcare value, drives evidence-based practice, gives healthcare guidance, and helps stakeholders make better choices.

R&D Funding

- **National Medical Research Council**
  The National Medical Research Council, established in 1994, oversees the development and advancement of medical research in Singapore. It provides research funds to healthcare institutions, awards competitive research funds for individual projects and is responsible for the development of clinician-scientists through awards and fellowships.

- **National Research Foundation (NRF)**
  NRF was established as a department in the Prime Minister's Office. The NRF sets the national direction for R&D by developing policies, plans and strategies for research, innovation and enterprise. NRF provides funding to MoH through NMRCalong with direct funding through fellowship and grants.

Academic & R&D Institutions

- **SingHealth (SingHealth Duke-NUS Academic Medical Centre)**
  A network of hospitals, national specialty centers, community hospitals, and polyclinics offering over 40 clinical specialties. Drives innovation to provide accessible and quality healthcare. Converges clinical care, education, and research.

- **National University of Singapore (NUS)**
  The oldest higher education institution and the first autonomous research university in Singapore. Has a research-intensive medical school that provides innovative education and research to transform the way diseases are understood, diagnosed, and treated.

- **Agency for Science, Technology and Research (A*STAR)**
  Leading public sector R&D agency. Bridges the gap between academia and industry through open innovation, collaborates both with public and private actors.

- **Singapore Clinical Research Institute (SCRI)**
  National academic research organisation dedicated to enhancing the standards of clinical research capabilities. Pilots scientific collaboration and research innovation to achieve better treatment outcomes for patients.

- **Consortium for Clinical Research and Innovation Singapore (CRIS)**
  Provides synergies and develops strategies for national-level clinical research under the stewardship of MOH. Brings together five entities:
  - Singapore Clinical Research Institute (SCRI)
  - National Health Innovation Centre Singapore (NHIC)
  - Advanced Cell Therapy and Research Institute Singapore (ACTRIS)

- Precision Health Research, Singapore (PRECISE)
- Singapore Translational Cancer Consortium (STCC)
- **Duke-NUS Medical School**
  Duke-NUS Medical School clinical research by providing senior disease experts and senior quantitative experts.
- **HealthTech Nanyang Technological University (NTU)**
  HealthTech NTU tackles health challenges with clinical precision, cutting edge research infrastructure, and expert interdisciplinary teams.

Healthcare Providers

- **Public hospitals**
  Provide 80% of healthcare (inpatient, outpatient, and emergency services) and employ the majority of medical staff. Clustered into 3 groups: National University Health System (NUHS), National Healthcare Group (NHG), and SingHealth
- **Private hospitals**
  Provide the remaining 20% of healthcare (clinics and hospitals). Generally offer better service level and minimum waiting times. Shared between two hospital groups: Parkway Pantai and Raffles Medical Group.

1.2. Financial and Service Scheme

Singapore's public healthcare philosophy is built on the following principle: citizens should be responsible for meeting their own and family healthcare needs through Singapore's "3M" (Medisave, Medishield, and Medifund) schemes. Along with this principle, the government develops initiatives to create a healthier population by encouraging preventive services and healthy lifestyles. This movement would keep healthcare affordable by controlling the supply side of this industry and providing substantial subsidies to public hospitals. For this purpose, in 2001, the government established the Health Promotion Board. Its mission is to provide "evidence-based health information that seeks to empower the Singapore public with knowledge and skills to take ownership of their health and live a healthy lifestyle." It is done through a wide range of health promotion and disease prevention programs, such as health and dental services for school children, workplace health programs, physical activity programs, etc[25].

There are three central regulatory agencies within Singapore's healthcare system: the Ministry of Health (MOH), the Central Provident Fund (CPF), and the Monetary Authority of Singapore (MAS). MOH is responsible for overseeing the provision of health services and regulations. Specifically, it is responsible for promoting healthy lifestyle choices, monitoring the availability and quality of health services, preventing and controlling diseases, allocating resources and experts, and managing the licenses required by health institutions[26].

The healthcare system of Singapore can be represented by the following scheme:

Healthcare financing in Singapore can be divided into two categories: public and private. Public financing via the Central Provident Funds (CPF) consists mainly of the "3M" (Medisave, MediShield, and Medifund) plus ElderShield (the latest initiatives of the four)[27].

The Central Provident Fund (CPF) is a comprehensive mandatory social security savings plan. The initiative ensures Singaporeans and permanent residents (PR) can support themselves once they are no longer working. CPF uses investment goals to meet the population's needs in retirement, housing, family security, asset improvement, and medical care. Workers and employers must make monthly contributions to the fund in three accounts, one of which is Medisave (used for hospitalisation expenses, approved outpatient medical care, and approved medical insurance)[28].

MEDISAVE

- National health insurance plan.
- 7-9% of monthly salary up to SGD 41K
- Pay for in-patient and outpatient treatment

MEDISHIELD

- Supplementary plan from Medisave
- For long-term hospitalisation and outpatient treatment of certain serious diseases
- Eligible for people under 85 years old

MEDIFUND

- Endowment fund by the government for excess healthcare expenses
- Approved amount depends on the financial, health, and social situation

ELDERSHIELD

- Auto-enrolment for citizens and permanent residents at age 40
- Monthly payouts of SGD 300 or SGD 400 per month for up to 5 or 6 years for elderly with severe disability.[29]

On the other hand, private financing comes from the premiums paid for private insurance services. Currently, there are five for-profit insurance providers, including American International Insurance, Aviva, Great Eastern Life, NTUC, and Prudential Insurance, all of which offer private health insurance plans for individuals and groups. These plans share similar coverage and benefits, such as inpatient and outpatient medical expenses, surgical expenses, treatment of critical illness, disability, and long-term care[30].

In Singapore, private insurance companies are regulated by the Singapore Actuarial Society (SAS), responsible for pricing, calculating reserves, and managing risks. It has the final authority in setting professional standards that private insurance companies must comply with[31].

1.3. Healthcare Providers

Public government-owned hospitals provide 80% of hospital care, including inpatient, outpatient, and emergency services. These hospitals are clustered into three groups: National University Health System (NUHS), National Healthcare Group (NHG), and SingHealth[32]. There are two leading private providers for hospital care: Raffles Medical Group and Parkway Pantai[33].

In 2020, there were 12,505 hospital beds in Singapore, including 9,610 public hospital beds and 1,650 private for-profit hospital beds, and 285 private non-profit hospitals. According to a 2019 survey, the number of registered doctors in public government-owned institutions (excluding specialists) and nurses were 9,030 and 26,079, respectively. The corresponding figures for the private sector are 4,439 and 11,180[34].

There are ten private hospitals in Singapore, along with a range of private clinics. Private hospitals tend to be smaller, offering shorter waiting times, more intimate rooms, and five-star quality care[35]. Doctors who operate at private hospitals are mainly business owners of their medical practices and tend to be more experienced due to higher salaries at such hospitals. Private hospitals have more budget to spend on new tech and innovative treatments as well[36].

Medical Tourism

Singapore receives 500,000 medical tourists each year. About 60 percent of them come from Indonesia, while the rest come from Malaysia, China, and other countries. Even though the country faces strong competition with neighboring countries in this aspect, the five main factors keeping Singapore attractive for medical tourism are the atmosphere and medical accuracy, competency and price, facilities, customer satisfaction, and entertainment[37].
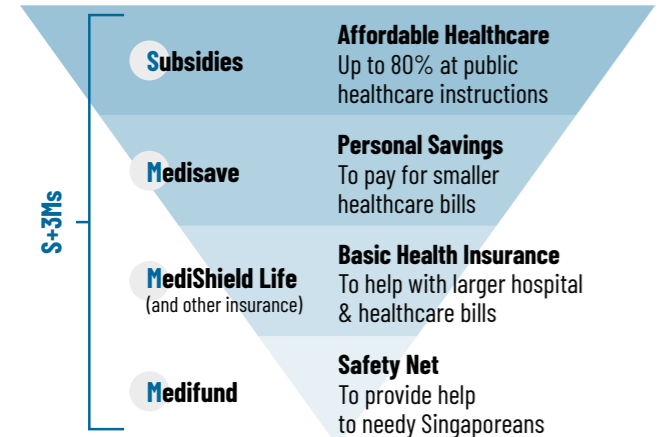
2. Healthcare Research & Development in Singapore

2.1. Healthcare R&D Overview and Current Strategy

Singapore has an established reputation as a center for scientific R&D in Asia, particularly in technology and biomedical sciences[38]. Since the early state development and rapid industrialisation in the 1980s, Singapore has invested heavily in Information and Communication Technology (ICT). The National Science and Technology Board (NSTB) was established in 1991 to boost Singapore's research and development sector. The Agency for Science, Technology, and Research (A*STAR) succeeded the NTSB, expanding the R&D focus to healthcare.

By introducing Biopolis in 2000, an international research and development hub for biomedical sciences, Singapore shows further commitment to developing biomedical innovation. Biopolis has, in the first ten years of its existence, borne at least five biomedical research institutes. Investments in biomedical research were fruitful, and Singapore saw a significant increase in research, publications, and patents made.

Singapore sets a development program every five years to define priorities and allocates significant funds (currently SGD 25 billion) to finance various research and innovation endeavors. One of the current plans (RIE 2025) is Human Health and Potential, including Health and Biomedical Sciences. This funding aims to foster economic post-COVID growth and address the problems of the aging population and low birth rates[39].

The Singaporean Agency for Science, Technology and Research (A*STAR) plays a unique role in the local R&D ecosystem. As the country's leading public sector R&D agency, A*Star bridges the gap between academia and industry through open innovation. Among others, its R&D activities include biomedical sciences: MedTech, pharmaceuticals and biologics, and biomedical research[40].

The non-exhaustive list of the most outstanding R&D institutes and centers in Singaporean Universities is as follows:

- Singapore Eye Centre
- Cancer Science Institute of Singapore
- Mechanobiology Institute, Singapore
- Bioinformatics Institute
- Bioprocessing Technology Institute
- Genome Institute of Singapore
- Institute of Bioengineering and Nanotechnology
- Institute of Medical Biology
- Institute of Molecular and Cell Biology
- Experimental Therapeutics Centre

Other prominent R&D actors in Singapore include:

- Biopolis - biomedical research and development (R&D) hub
- S*BIO - a biotech company focused on the research and clinical development of novel targeted small molecule drugs for cancer treatment.
- Drug Discovery and Development Unit (D3) - a national platform for drug discovery and development set up in 2019.

S+3Ms	Subsidies	**Affordable Healthcare** Up to 80% at public healthcare instructions
	Medisave	**Personal Savings** To pay for smaller healthcare bills
	MediShield Life (and other insurance)	**Basic Health Insurance** To help with larger hospital & healthcare bills
	Medifund	**Safety Net** To provide help to needy Singaporeans

Source: https://dollarsandsense.sg/your-complete-guide-to-healthcare-financing-in-singapore/

2.2. Innovation Flow from R&D to End-User Implementation

Today, R&D initiatives and implementations stem from both national interests and hospitals' or groups' interests. As mentioned earlier in this report, the Singapore healthcare system is clustered into NUHS, NHG, and SingHealth. Three clusters have different approaches in building their research agenda. For instance, NHG focuses more on downstream and clinical research, less on basic educational research, unlike NUHS, specialising in prevalent diseases in Asia.

Hospitals under the clusters have the independence to decide the R&D to conduct based on the urgency of the issues. In terms of funding, the hospitals might use patient revenue for a relatively small project. However, fundraising to MOH is likely for more extensive endeavors. Fundraising has nonetheless become competitive among hospitals or clusters. Healthy competition for funding from MOH and NRF exists between clusters.

Existing Regulation to Support Business/Products' Market Expansion

The Health Products Act and the Health Products (Medical Devices) Regulations govern all importation of medical devices. Singapore's Health Sciences Authority (HSA) is in charge of the statutory regulatory system that ensures the quality, safety, and efficacy of medical devices sold in the country. HSA must approve any importation of medical devices before introducing them to the Singaporean market or distributing them from Singapore. The HSA also classifies medical devices into various classes according to risk factors. Almost every medical device is subject to regulatory oversight. Class A products or devices considered low risks are exempted.

Product registration is required for Class B, C, and D[41]. HSA guideline is informed by the Global Harmonisation Task Force, an inter-governmental body established to promote convergence in standards and practice relating to the regulation of medical devices. For EU companies, the reference regulatory agency is European Union Notified Bodies (EU NB), where some approvals from EU NB are eligible when registering the device in Singapore. ASEAN has been working on a unified system for registering and evaluating medical devices among its members[42].

While having a stringent consumer protection regime, Singapore also supports intellectual property rights in favor of privatised R&D facilities to break ground locally. Singapore is a signatory of the WTO's TRIPS (Trade-Related Aspects of Intellectual Property Rights) which ensures the protection of registered patents. This protection, coupled with vigorous enforcement of contracts, shows that Singapore has a robust IP regime, both for individuals and businesses.

The government also provides tax incentives for R&D activities. These incentives include tax deductions and policies preventing double taxation, ensuring that the country only taxes companies with a registered entity. For a curated list of relevant regulations, see Appendix B

2.3. SWOT Analysis on R&D Landscape in Singapore

The following SWOT analysis is done and summarised for assessing Singapore's Research & Development sector.

STRENGTH	WEAKNESS
• Global Science and Technology R&D center • Connectedness within the city • Supportive regulatory environment • Tax incentives for skills development • Strong S&T infrastructure	• Shortage of managerial staff and S&T talent • Risk-taking entrepreneurial culture yet immature • High cost of R&D (technology and manpower) • Funding gaps at later stages of companies' growth
OPPORTUNITY	**THREAT**
• Favorable business climate • Early stage funding easily available • Strong protection of IP rights	• Talent retention in the face of international competition • Talent shortage

Strength

Singapore is reputed to pioneer innovation, science, and technology open for foreign specialists and businesses. A vibrant ecosystem supports R&D across governmental agencies and institutions, universities, private funds, and more. Singapore has a highly diverse and well-educated population, and a solid manufacturing base initially built for electronics and precision engineering. In addition, Singapore has deep expertise in providing financial support to international businesses[43].

Singapore is unique in the density and interconnectedness of its governmental, scientific, technological, and business networks as a city country. It offers tremendous advantages for R&D initiatives since everything is well-networked and can be easily scaled.

The Singaporean government also provides other tax incentives for entities conducting R&D activities in Singapore to produce patented solutions[44]. It subsidises partially funded traineeship and internships as part of its initiative to ensure that the local population can gain valuable skills despite the economic downturn[45].

Another considerable advantage the country offers is its pioneering sandbox regulatory approach: the one that "allows live, time-bound testing of innovations under a regulator's oversight[46]." It provides a safer and easier-to-access space for testing innovations under existing regulations or even outside of them, at the same time reducing their costs. This approach also allows a dialogue between market players and regulators, providing a compromise between facilitating innovation and managing risks[47].

A 2019 study by the Economic Survey of Singapore demonstrated that the government's R&D funding efforts have been paying off: between 2002 and 2017, a one percent increase in R&D stock in a company led to a 0.135 percent increase in productivity on average. In monetary terms, an SGD 1 increase in R&D stock increased productivity by SGD 0.24 in an average company. The overall conclusion is that R&D funding should continue[48].

Weakness

Multiple sources indicate that while the R&D landscape is extensive and diverse in Singapore, there are not enough skilled managers to lead R&D-driven businesses, technology- and commerce-wise[49], and the general shortage of Science & Technology talent. Employing highly-skilled foreign workers would incur higher costs as companies will need to sponsor them with an Employment Pass (EP). This issue is currently further exacerbated by the immigration restrictions imposed due to Covid-19.

Another challenge is that Singapore is still relatively new in this arena. The risk-taking and entrepreneurial spirit are still immature compared to the likes of Silicon Valley. There is also a potential gap in employing and managing both scientists and entrepreneurs as these two often require opposite qualities.

Since Singapore is a developed country with a high living standard, R&D costs are high and require a significant budget. An early-stage investment is widely available here. However, funding gaps may appear at later stages of companies' growth when profits are not yet there, but more investment is still needed[50].

Opportunity

Singapore is very well ranked in terms of business climate. For instance, Siemens and Medtronics have chosen Singapore as the location for their regional headquarters[51]. Considering a strong intellectual property regime (ranked in top 5 globally[52]) Singapore is seen to be a perfect place for developing new products and solutions that can be exported to the larger ASEAN market.

Singapore provides a vibrant network of possible funding sources for S&T startups, both public and private. It is possible to obtain funding through crowdfunding, angel investors, venture capitals, incubators, and government funding. For this reason, it is often seen as a place to start a business for foreign entrepreneurs and investors. At the same time, it is a place where they are assured of diligent protection of their intellectual property.

Threat

Singapore's R&D landscape is under a real threat of labor migration towards other countries, such as Indonesia, Thailand, or Malaysia. The S&T talent shortage is already perceptible in Singapore; however, it will compound as the sector grows. The government has been aware of this trend. In 2019 it launched a two-year pilot Tech @ SG to help tech companies recruit foreign talent to stem this loss[53].

Another general threat is related to data security. The growing threats of data theft and misuse make it primordial for companies to search for protection; however, cybersecurity specialists are also in short supply. Singapore has recently seen an increase in cybercrime and admits that despite all the technological efforts to prevent it, the human factor keeps information systems vulnerable[54].

3. Appendix A: Key Players of Singaporean Healthcare Industry

The companies listed below are medtech, pharmaceutics, and genomic industries players, with primary headquarters in Singapore. The below companies indicate heavy R&D activity in their product development. We included companies of all sizes, from startups to publicly listed corporations, to provide an accurate snapshot of the local landscape.

Company	Industry (Genomics/ MedTech/ Others)	R&D Focus
Alchemy Foodtech		
Platform offering plant-based carbohydrate food ingredients. The company develops novel food ingredients that fight diabetes prevention. Its patented plant-based ingredient helps slow down the glucose release of refined carbohydrate foods and slows down the digestion of white rice to the same as brown rice. Its product offerings include white rice, brown rice, white bread, white buns, wholemeal bread, wheat noodle, brown rice pasta, etc. The company claims to combine food, bio, and medical technologies for its production.	Others	Internal Product R&D
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 nanoim-printing. 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
Surgizip		
A surgical zipper used for closing surgical wounds using bio-adhesive technology. It uses a breathable microporous material having perforated holes serving as blood drainage.	Others	Internal Product R&D
Aslan Pharmaceuticals		
ASLAN Pharmaceuticals is an oncology-focused company developing a portfolio of targeted drugs, focusing on gastric, bile duct and breast cancers. The Company's proprietary pipeline of 4 development-stage candidates addresses multiple indications including gastric and breast cancers and inflammatory diseases. ASLAN's most advanced compounds are ASLAN001 which is pan-HER inhibitor with phase 2 data in gastric cancer, being developed in cholangio-carcinoma, breast cancer and gastric cancer, and ASLAN002, which targets RON, an immune checkpoint inhibitor, and cMET receptor tyrosine kinases, being developed in gastric and breast cancer	Others	Internal Product R&D
MerLion Pharmaceuticals		
MerLion Pharmaceuticals is developing fluoroquinolone-based therapeutics for bacterial infections. Its lead product, finafloxacin, is a fluoroquinolone in clinical development for treating serious bacterial infections in the hospital and critical care through intravenous and oral therapy. Finafloxacin selectively inhibits bacterial type II topoisomerase enzymes, DNA gyrase and topoisomerase IV which are required for bacterial DNA replication, transcription, repair and recombination	Others	Internal Product R&D
MegaChem		
Megachem is involved in contract manufacturing service for a diverse range of chemical products. They offer manufacturing services including liquid blending, solid blending, repacking, and auxiliary services. They distribute a wide range of products having applica-tions in performance coating, polymers, agricultural, pharmaceutical, flavor and fragrance, oil, and gas industries.	Others	Internal Product R&D

Biopsin		
BIOPSIN has developed a microbial detection system for testing food, beverages, water, consumer goods, and pharmaceutical products. The system extracts and traps the pathogenic microbes from the products to analyse and provides quantitative results at the single-cell level.	Others	Internal Products's R&D
Hyphens Pharma		
Hyphens Pharma manufactures specialty pharmaceuticals, proprietary drugs. Their products are of various therapeutic categories including allergy, otorhinolaryngology, dermatology, gastroenterology, obstetrics, ophthalmology, pediatrics, radiology, and interventional cardiology.	Others	Internal Products's R&D
SRS Life Science		
SRS is discovering & developing avant-garde drug deliveries and formulations for the pharmaceutical and healthcare industries. The company's product portfolio includes lollipops (nutraceuticals), Unistraw (straw delivery systems), taste masked portable antibiotic sachets, single dose syrups, hydrogel therapy (buccal absorption technology), Chewbiotics (chewable antibiotics), etc. The clientele includes Abbott, Bayer, Merck, Novartis, Sandos, Pepsico, etc.	Others	Internal Products's R&D
Visuho		
Vishuo Biomedical is a Singapore based healthcare technology company that offers genomic sequence analysis to research institutes, health screening clinics, hospitals, and the pharma-ceutical industry. The company's iCMDB (individual Customised Database) platform analyses the data using the proprietary algorithm and statistical methods. Results are summarised in a report. iCMDB is certified by ISO13485:2003, and classified as a Class A medical device by Singapore HSA.	Genomics	Internal Products's R&D

AIM Biotech		
A spinout from MIT, AIM Biotech develops and manufactures microfluidic devices for research applications, beginning with 3D cell culture systems. AIM's 3D cell culture chips enable multicellular models to be established in extracellular matrices of the users' choice (e.g. collagen, Matrigel, etc.). Stable gradients of pressure or chemicals can be established to model interstitial flow or concentration gradients respectively. Applications developed to date include cell migration, angiogenesis, cancer metastasis (intra-/extravasation, spheroid dispersion), chemotaxis and stem cell differentiation. These models can also be used for screening compounds that affect these biological processes. AIM chips are consumables designed to be used with standard cell biology lab equipment without the need for new capital expenditures. AIM Biotech will supply chips & accessories to the research community initially, and will expand into the provision of testing services for the pharmaceutical industry. Some key features of AIM microfluidic chips are - Long working regions that are easily injectable with hydrogel, with low risk of leakage; Gas permeable bottom laminate ensures accurate reflections of incubator conditions (normoxic or hypoxic); Multicellular co-culture, with meaningful organisation into models of biological systems; Control over chemical gradients and flow across the gel region and/or within the media channels. AIM claims its chips provide easy to cast hydrogels for 3D cell culture, and provide excellent optical clarity for various imaging techniques.	Others	Internal Produtct's R&D

PharmChem Pacific Asia		
Pharmachem Pacific Asia is engaged in the manufacturing and marketing of nutraceutical and pharmaceutical ingredients. Ingredients offered include vitamins, minerals, herbs, and botanicals. The company sells its products in bulk quantities.	Others	Internal Produtct's R&D

ChemoPower		
ChemoPower provides chemical composition identification solutions. The company has its proprietary core technologies. The company developed software which uses mathematical models to reconstruct pure components' spectra and its concentration without prior information. The software uses experimental data without any simulation or peak matching. The company also performs chemical composition analysis for the pharmaceutical, traditional medicine, environmental, food along with rapid quality assurance and quality control assessments.	Others	Internal Produtct's R&D

ICM Pharma		
CM Pharma offers contract manufacturing service. They manufacture tablets, capsules, creams, ointments, lotions, and syrups. The pharmaceutical products are of various therapeutic categories including dermatological, gastrointestinal, analgesics, and others. The company also offers herbal supplements, cosmetics, perfumeries, toiletries, pet care products, household products, detergents, and general chemicals. The company has manufacturing facilities certified by GMP.	Others	Internal Produtct's R&D

Stanso Pharmaceuticals		
Stanso Pharmaceuticals offers contract manufacturing services for finished dosage forms such as tablets, capsules, powders, and liquids. The products are of various therapeutic categories including anti-inflammatories, anti-histamines, anti-ulcers, haematinics, etc. The company has manufacturing facilities certified by WHO-GMP.	Others	Internal Produtct's R&D

eResidue		
eResidue provides validation software for the pharmaceutical industry. It provides software designed for calculating limits for activities and cleaning agents in drug product manufacturing. Their platform is cloud-based. The platform provides constant reports, thereby increasing productivity and maintaining traceability.	Others	Internal Produtct's R&D

Cubicpharma		
Cubicpharma offers consulting services to pharmaceutical, medical devices, biologics, cosmetics industries. They offer consulting services for quality assurance, regulatory affairs, engineering, automation and controls, and contract manufacturing. The company has manufacturing facilities certified by ISO 9000 / ISO13485.	Others	Internal Produtct's R&D

AxisMed Research		
AxisMed Research is a site management organisation that supports clinical trials for pharmaceutical, biotechnology, and medical devices. It offers services such as feasibility evaluation, non-disclosure & clinical trial agreements, site selection, trial finance, budgeting and costing, recruitment, site monitoring, audit, etc.	Others	Internal Produtct's R&D

HolosLife Sciences		
Holos Life Sciences is a company focused on the discovery and development of epigenetic biomarkers. They develop biomarkers utilising chromosome conformation signatures (CCS). Their patented EpiSwitch is utilized for the identification of CCS. They develop biomarkers that enable the non-pharmaceutical enhancement of health, wellness, and performance in humans and animals. It also helps to improve the diagnosis and prognosis of mild Traumatic Brain Injury	Genomics	Internal Produtct's R&D

Poli Medical		
Poli Medical manufactures natural herbal based pharmaceutical products and supplements. They manufacture various dosage forms including capsules, powders, liquids, sachets, and syrup. The pharmaceutical products are of various therapeutic categories including anticold, analgesics, vitamins and minerals.	Others	Internal Produtct's R&D

Taiho Pharma Singapore		
Taiho Pharma Singapore manufactures finished dosage forms like tablets, capsules, etc. The products are of various therapeutic categories such as antibiotics, analgesics, gastrointestinal, oncology, and others.	Others	Internal Produtct's R&D

CMIC Asia-Pacific		
CMIC Asia-Pacific offers clinical research management services to pharmaceutical, biotechnology, and medical device companies in China, Korea, Taiwan, Hong Kong, Singapore, Malaysia, Thailand, Vietnam and other Asian countries. Their service portfolio includes clinical development, consulting, post marketing research and commercialisation services. They claim to have experience in developing NCEs, biologics, advanced therapeutic products, medical devices and orphan drugs. They also offer their services for investigator-initiated trials, observational studies and registry studies. Expertise in country-specific regulations and medical practices and established relationships with local investigators are their USPs.	Others	Internal Produtct's R&D
Glopharm		
Glopharm manufactures Active Pharmaceutical Ingredients as well as finished dosage forms like tablets, capsules, syrup, etc. The finished products are of various therapeutic categories including antibiotics, antifungal, anti inflammatory, and others.	Others	Internal Produtct's R&D
Aerosense		
Aerosense manufactures multiple parameter sensors. Its products include sensors to measure differential pressure, temperature, relative humidity, carbon dioxide, carbon monoxide, and air quality. The sensors have applications in multiple industries including HVAC, pharmaceutical industries, home and building automation, etc. The company also provides OEM services to its customers.	Others	Internal Produtct's R&D
Adept Precision Qualification		
Adept Precision Qualification provides consulting services for manufacturing solutions to pharmaceutical, food, and beverage (F&B), and logistics industries. They offer services for thermal mapping, on-site calibration, V-model project management, installation, operational, logistic transportation, monitoring qualification consultation, etc.	Others	Internal Produtct's R&D
Acertus		
Acertus is a group of companies which has 2 major divisions - Acertus Pharma and Acertus Biotech. The pharma division is engaged in the development, commercialisation and marketing of proprietary products under license agreements. Their portfolio includes pharmaceuticals, dermatologicals, nutraceuticals, diagnostic and consumer products. The company has signed agreements with Antares Pharma for the use of their Transdermal Gel technology for hormonal delivery and local dermal delivery of APIs. Their biotech division offer services for the development of biosimilars through their experience in molecular biology, recombinant protein production, bacterial and mammalian cell fermentation, downstream processing, formulation, filling and package design.	Others	Internal Produtct's R&D

Opto Pharm		
Opto-Pharm is a CMO engaged in the manufacture of sterile pharmaceuticals and contact lens care solutions. Their portfolio includes eye-wash, sterile wash and eye drops and contact lens care solutions such as saline and other multi-purpose solutions and comfort drops.	Others	Internal Produtct's R&D
Austex Pharma		
Diversified pharmaceutical company offering various OTC products	Others	Internal Produtct's R&D
Beacons Pharmaceuticals		
Beacons is engaged in manufacturing generic formulations for other pharmaceutical companies. The dosage forms offered include tablets, capsules, syrups, and fluids of various therapeutic categories.	Others	Internal Produtct's R&D
Medisix Therapeutics		
Medisix Therapeutics is developing CAR-T based therapies for the treatment of cancer. The company has developed a technology platform based on genetic engineering to generate T cells for leukemias and lymphomas and for treatment of leukemias and lymphomas.	Others	Internal Produtct's R&D
Entropical Labs		
Entropica Labs provides quantum computing tools for bioinformatics and genomics.	Others	Internal Produtct's R&D
Sengenics		
Sengenics is a genomics and proteomics based diagnostics and research company. Sengenics' flagship product is their patented Immunome autoantibody profiling protein array for use in immunology or cancer research. The Immunome platform was jointly developed by Cambridge and Oxford Universities and is the only protein array platform where all proteins are correctly folded. Apart from their proteomics product, the company offers genom-ics-based diagnostics services from its CLIA and CAP certified labs using NGS and microarray technologies. The company offers postnatal diagnostics, cardiac and cancer risk tests, and developmental delay diagnostics, along with Sequenom's NIPT - MaterniT21 and VisibiliT tests. The NIPT tests are carried out at Sequenom's CLIA and CAP accredited laboratory. Along with their clinical tests, the company also offers research services to clients in biomarker discovery, NGS, and Bioinformatics.	Genomics	Internal Produtct's R&D
Novena Global Lifecare		
Novena Global Healthcare provides DNA testing services for preventive healthcare solutions to consumers. The company offers stem cell treatments and DNA testing centers to treat and diagnose inheritable diseases. It gives health screening tools for disease detection, nutritional supplements and more.	Genomics	Internal Produtct's R&D

Lucene		
Lucene is a developer of genomic tests for the treatment of cancer. It has developed precision oncology genomic tests that are non-invasive blood tests that help in the detection and improve treatment selection. Genomic medicines help in the detection of cancer before symptoms show and check for genetic risk of developing cancer. It has developed a SAFER Sample that is a proprietary formula of virus transport medium that preserves viral ribonucleic acids at room temperature for up to a week without the need for chilling. It is a non-invasive specimen collection & helps in the transport of samples. The product is compatible with qPCR testing procedures.	Genomics	Internal Produtct's 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 Produtct'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
Global Gene Corp		
Global Gene Corp provides population-specific genetic testing services. Its proprietary IndiaCHIP tests for a panel of single nucleotide polymorphisms (SNPs) that are associated with Indians and diseases such as diabetes, hypertension and other metabolic disorders, hereditary cancers, carrier testing, hormonal disorders and other diseases. In addition, the company partners with biopharma companies to drive targeted drug discovery and development. It is headquartered in Singapore, and has offices in India and an R&D Center at the Wellcome Trust Center Uk. In Feb 2017, Blippar co-founder Ambarish Mitra led a consortium that invested in Global Gene Corp, which also included Nestle's Nandu Nandkishor.	Genomics	Internal Product's R&D

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
Imagene Labs		
Imagene Labs develops saliva-based direct-to-consumer personal genomics solutions. The company performs all high throughput genetic tests on Illumina DNA-microarray chips. Its product range, marketed under the brand name Ori, consist of three groups of tests for fitness (Ori FIT, FIT+ and FIT PRO+), skincare (Ori SKIN, SKIN+ and SKIN PRO+) and nutrition (Ori VIT and VIT+). A combined fitness, skincare and nutrition gene panel (OriLIFE+) is also available. Prices range from SGD169 to SGD399 for the panels, with the higher priced panels also offering customised recommendations for nutritional supplements and skincare products according to the results of the gene panel.	Genomics	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
Novostrata		
Novo Satra is developing non-invasive diagnostic tests for cancer. It uses an Oxford-developed epigenetic platform to diagnose the presence of cancer-based on gene expression patterns and the presence of specific non-coding RNA. The first application is breast cancer.	Genomics	Internal Product's R&D
Lambdagen Therapeutics		
LambdaGen Therapeutics provides personalised stem-cell based therapeutics. It offers its proprietary non-viral genome insertion system which is based on the Ø-integrase gene. It also offers its platform LIGIT (Lambda-Integrase Genome Insertion Tool) for non-viral Ø-integrase-mediated site-specific recombination. Its products are being used in the treatment products for the treatment of Hemophilia A, Wilsons disease among others are under the pipelines and is in the discovery stage	Genomics	R&D Partnership with Singapore-MIT Alliance Research Technology (SMART), NTU, NUS, A*Start, Kings's College London, UC San Diego

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
Angsana Molecular Diagnostics		
Angsana Molecular and Diagnostics Laboratory provides genomic testing based personalised medicine. It offers tests, assay, and technology by combining molecular and genetic profiling to target innate immunity and provide prescribed medicine for the individual. It offers tests for oncology, fetal and mother tests before and after birth, allergy testing, and pharmacogenetics. They offer tests following the Sanger sequencing and provide information to clinician and patient both for deciding the treatment and medicine. It is certified by CAP.	Genomics	Internal Product's R&D
Chromozoom		
Chromozoom provides gene-based tests for personalised lifestyle and healthcare plans. It offers its proprietary DNA tests like ChromozoomNUTRI, ChromozoomDerma, Chromozoom-Dental, and others which are used to detect genetic markers and 200 linked genes providing personalised data like nutrition, health, physical activity, and others.	Genomics	Internal Product's R&D
iGene		
iGene Laboratory provides a non-invasive genetic test done by blood samples of the mother. It detects the cell-free DNA (cfDNA) which enters the mother's bloodstream via the placenta. It screen for Trisomy 21 (down syndrome), 18 (edward syndrome), 13 (patau syndrome), sex chromosome aneuploidies (turner syndrome, jacab syndrome etc.) and selected deletion syndromes.	Genomics	Internal Product's R&D
Guardant Health		
Provider of a technology platform for the diagnosis of cancer using AI. The company's products include Guardant360 that is a cancer diagnostic assay. It is used to detect genomic variations in oncogenes responsible for solid tumours and also detect microsatellite instability-high (MSI-high). The company uses its proprietary Digital Sequencing technology with machine learning for comprehensive genomic profiling used in immuno-oncology. The company's other product, GuardantOMNI is used to analyse the genome of cancer patients for their clinical program. It is also used to monitor patient response to investigational drugs/ combinations of drugs.	Genomics	Internal Product's R&D
Avatmed		
AVATAMED is a developer of drugs for cancer treatments. It has developed precision oncology services that help to analyse the genomic characteristics of an individual. It also helps to investigate the immune cell population and targeted anticancer drug screening virtual clinic response tests.	Genomics	Internal Product's R&D

Asia Genomics		
Asia Genomics is a Molecular Diagnostics Company specialising in Clinical Genomics & Genetic Testing Vision. Provides genetic testing services for cancer (somatic & hereditary), reproductive (Non-Invasive Prenatal Test & Carrier Screening) and for hereditary cardiovascular disorders. Also provides genetic counseling services to patients and physicians.	Genomics	Internal Product's R&D
Xylonix		
Xylonix is the developer of cancer immunotherapy. Its proprietary technology Onco-Part-hanatos kills and turns cancer into its own inflammatory antigens and initiates anti-cancer immune responses. Its pipeline products include XNX-C005D, XNX-C008D that target site-ag-nostic cancer indications of genomic instability mutations, and a predictive serum biomarker reflecting tumor microenvironment.	Genomics	Internal Product's R&D
Genosys		
Genosys offers genomic big data analytics and visualisation platforms. The platform allows users to collect genomic big data and analyse data to capture gene expression insights, gene regulation analysis, and multi-omics data. It caters to scientific, life science, healthcare and agricultural research industries. Its product includes Mendel Analytics which allows users to analyse and visualise NGS and PacBio sequencing data. It also provides reports with high clarity images and visuals, data interpretations and manages queries	Genomics	Internal Product's R&D
Genes		
Genes Chain provider of block-chain based genomic databases service platform. It offers genomic-based big data generation, storage, mining, sharing, and others. It helps in providing healthcare improvement data, and data sharing for scientific research.	Genomics	Internal Product's R&D
Genomax Technologies		
Genomax Technologies provides solutions in the field of genomics, proteomics, bioinformatics and molecular & cell biology. Its services include microarray experiments for gene expression, miRNA, aCGH, ChIP-on-chip and methylation, custom antibody and peptide production, custom cDNA library construction service and other molecular biology services.	Genomics	Internal Product's R&D
Base Asia		
1st Base is a biotech company offering various services to the life sciences research community. The company focuses on DNA sequencing, Next Generation Sequencing, molecular biology services, fragment analysis, peptide synthesis services, antibody development and production, proteomics services, and metabolomics services. The company also manufactures biochemicals and buffers for laboratory use.	Genomics	Internal Product's R&D

Vela Genomics		
Vela Genomics is leveraging expertise in bioinformatics and clinical curation to create their TheraKey cloud-based interpretation system. The TheraKey system accepts clinical sequencing data in the form of VCF files, which it analyses to determine actionable variants which are then mapped to therapies (FDA approved, off-label, investigational drugs), and worldwide recruiting clinical trials to guide clinical decision-making.	Genomics	Internal Product's R&D
Suprenom		
Uprenom offers nucleic acid purification kits. The products include gel advanced gel extraction kit, PCR advanced PCR purification kit, plasmid DNA extraction kit, blood and tissue genomic DNA extraction kit, total RNA extraction kit, plant genomic DNA extraction kit, plant total RNA extraction kit, nucleic acid purification, and others.	Genomics	Internal Product's R&D
Straits Biotech		
Stratis Biotech offers genomics services to the life science community. The service portfolio of the company comprises Genotyping, Molecular Breeding, Genetic Purity, Quality Control, and Trait Discovery. The company has an in-house Laboratory Information Management System (LIMS) to ensure tractability and accuracy.	Genomics	Internal Product's R&D
MaVie		
Developer of DNA kit to monitor DNA or genetic wellness	Genomics	Internal Product's R&D
Axil Scientific		
Axil Scientific offers a variety of products and services including DNA sequencing services, Next-Generation sequencing, Fragment analysis services, Peptide synthesis, Antibody production, Proteomics services, Biochemicals, Buffers and reagents, Molecular biology services, Life science research products, Molecular and cellular biology services, Immunology instruments, and Labware.	Genomics	Internal Product's R&D
DNAcode		
DNAcode offers genetic tests for health and nutrition. The tests offered by the company provide personalised results for individuals related to skin care, ancestry, and fitness. Users can purchase a saliva sample kit online. DNA data collected from the sample is analysed for providing personalised recommendations on nutrition, exercises, wellness, etc	Genomics	Internal Product's R&D
Callvecc		
Cellvec is a gene therapy contract development and manufacturing organisation. It provides services like custom viral vectors for pre-clinical and clinical applications, fully functioning recombinant lentiviral vector contract manufacturing service to GMP standards, quality assurance, develop gene transfer producer system, develop molecular, expression construct, develop up-scale technologies, and purification and concentration process.	Genomics	Internal Product's R&D

Probioscience Technologies		
ProBioscience is developing diagnostic reagents and kits. The company has developed products such as protein array, ELISA, multiplex kit, molecular reagents, PCR and lab cleansing reagents among others. The company also provides services such as immune protein services, and genomic services for the research purpose. It also provides instruments such as flow cytometry, incubator, ultrasonic bath and oven among others.	Genomics	R&D Partnership with A*Star
Aclot		
Aclot engages in providing molecular biology reagents to the life science industry. The product portfolio of the company comprises recombinant proteins, cDNA gene/clones, blood, serum, cell culture and molecular biology reagents. Additionally, the company also offers Next generation sequencing services.	Genomics	Internal Product's R&D
Xfinity Labs		
XfinityLab is a provider of internet first clinical labs for genetic tests. The lab helps individuals to optimise their health based on their unique genetics. It provides a tool that explains how DNA affects their diet, exercise, and nutrition. It empowers individuals and physicians to make more informed decisions about overall health through genomic technology. It offers multiple genomic tests such as health & wellness, personalised medicine, caris molecular intelligence tumor profiling, HLA drug hypersensitivity, and many more	Genomics	Internal Product's R&D
ScienceWerke		
Sciencewerke provides genomic services, instruments, reagents, and consumables to biotech and pharma industries. They provide services including genomic services (array prototyping, gene expression, genotyping), epigenetics, bioinformatics, life science reagents (western blotting reagents, small molecules, peptides, and antibodies), and instruments. The company has manufacturing facilities certified by ISO 9001: 2008.	Genomics	Internal Product's R&D
SimplyScience		
Simply Science offers next-generation DNA sequencing services. They use the instruments of companies such as RBC Bioscience, Biotools, Omega Biotech, and others. They offer sequencing services including DNA extraction service, Avian DNA services (Avian DNA sexing), and custom services.	Genomics	Internal Product's R&D
Genovate		
Genovate offers a range of DNA testing services. Tests offered by the company include paternity test, maternity test, Sibling test, grandparent test, DNA cousin test, twin test, cardiovascular health test, skin health test, etc.	Genomics	Internal Product's R&D

Baby DNA		
BabyDNA offers DNA test kits for paternity determination. The company offers tests for paternity determination, maternity, grandparentage, sibling, aunt, uncle, etc. They provide kits that consist of sample collectors like swabs or hair samples.	Genomics	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
Molecular Genomics		
Molecular Genomics provides Microarray-based Genomics Analysis. It offers gene expression (GE), array comparative genomic hybridisation (aCGH), chromatin immunoprecipitation (ChIP-on-chip), DNA methylation, or microRNA (miRNA) services. It offers a complete portfolio of the Agilent microarray platform, custom microarray services and next generation sequencing services.	Genomics	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
SDT Molecular		
Manufacturer of molecular diagnostic assay for research	Others	Internal Product's R&D
Fluigen		
Fluigen has developed portable waterborne pathogen detection and monitoring systems for municipal and industrial applications. The company's high-flux sample concentrator captures biological samples of water for online monitoring operations. Provides a disposable Fluidi-cOne card which uses /microfabrication, thermal and microfluidics engineering techniques for rapid detection of waterborne pathogens.	Others	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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