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MINISTRY OF HEALTH
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INTERNSHIP REPORT

DATA ANALYTICS DIVISION INTERN

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1. Background

1.1. Ministry of Health, Singapore

Ministry of Health (MOH) is an innovative, people-centred organisation, committed to medical excellence, the promotion of good health, the reduction of illness, and access to good and affordable healthcare for all Singaporeans, appropriate to their needs.

Through MOH, the Government manages the public healthcare system to ensure that good and affordable medical services are available to all Singaporeans. MOH achieves this by providing subsidised medical services while promoting individual responsibility for the costs of healthcare services.

While the SG population is encouraged to adopt a healthy lifestyle and take responsibility for their own health, safety nets are in place to ensure that residents are provided with affordable healthcare.

The public healthcare delivery system is geographically structured into three healthcare clusters: National University Health System (NUHS), National Healthcare Group (NHG) and Singapore Health Services (SHS).

The work of MOH is implemented through its three main groups: Policy and Corporate Group, Operational Groups, Professional Cluster.

MOH also licenses and regulates all healthcare establishments such as hospitals, nursing homes, clinical laboratories, medical and dental clinics.

1.2. Data Analytics Division

The Data Analytics Division (DAD) at MOH is a team of data scientists, data analysts, and health economists that apply artificial intelligence (AI), machine learning (ML), operations research, systems modelling, geospatial analytics, forecasting, econometrics, visualisation, and primary research in support of MOH's priorities in policy formulation and review, service planning, and operations. The division develops health AI strategy and builds ecosystem enablers such as AI governance, data and IT platforms, and deploys impactful, scalable, responsible AI solutions in healthcare. The division is responsible for capability development, publication, partnership, and outreach with respect to data analytics and AI in MOH.

1.3. Healthier SG

Healthier SG is a major transformation initiative of Singapore's healthcare system. The initiative intends to shift the emphasis from reactively caring for those who are sick, to proactively delaying the onset of chronic illnesses.

To achieve this, MOH intends to anchor Singapore residents with a family doctor, and foster community support for healthier lifestyles. Healthier SG aims to prevent or delay the deterioration of health, reduce the burden on loved ones, extend healthy life years and improve residents' quality of life. It will also moderate the increase in healthcare expenditure over time.

Such an initiative will help address two major challenges that lie ahead for Singapore:

- One in four citizens are expected to be 65 and above by 2030, up from one in six today. As people get older, they are more likely to fall sick or suffer from disabilities.
- The prevalence of chronic diseases such as hypertension and hyperlipidaemia has risen to worryingly high levels, at 32% and 37% of SG population, respectively, in 2019-2020. Together, these challenges will cause significant health, emotional and financial burden on individuals and families in the coming years. Decisive action need to be taken to prevent or delay the onset of ill health, and slow or even reverse these trends.

Healthier SG is designed with these objectives in mind. There are five key features –

1. Mobilise family doctors to deliver preventive care for residents
2. Develop health plans that include lifestyle adjustments, regular health screening and appropriate vaccinations which doctors will discuss with residents
3. Activate community partners to support residents in leading healthier lifestyles
4. Launch a national enrolment exercise for residents to commit to seeing one family doctor and adopt a health plan
5. Set up necessary enablers such as IT, manpower development plan and financing policy to make Healthier SG work

MOH will work closely with the healthcare clusters, family doctors, and community partners to implement these features (MOH, 2022).

2. Internship Project

2.1. Systems Dynamic Modelling

The objective of the project was to develop a systems dynamic model that could quantify and simulate the impact of Healthier SG features on chronic disease prevalence, infection, and healthcare utilization in Singapore.

A systems dynamic model is a continuous simulation model that uses hypothesized relations across activities and processes, dealing with complex data and datasets (Olson, 2003). This model goes beyond the traditional individual information processing level, engaging more actively in the relationship between an operator, tasks, and contexts. This systems approach is expected to have more room to embrace affective elements in the model (Jeon, 2017).

In the context of chronic diseases, a system dynamics model seeks to incorporate all the basic elements of a modern ec ological approach, including disease outcomes, health and risk behaviours, environmental factors, and health-related resources and delivery systems. System dynamics shows promise as a means of modelling multiple interacting diseases and risks, the interaction of delivery systems and diseased populations, and matters of national and state policy (Homer & Hirsch, 2006).

Cognizant of the internship timeframe of six months, the goal was to develop a model from ground up that could split the Singapore population into different health states and estimate and project the utilization of healthcare services for different scenarios.

The calculations, projections, and simulations done by the model will help MOH to efficiently assess costs and resources required to meet healthcare needs of the Singapore population in the future once Healthier SG programme takes effect.

2.2. Data and Tools

Select datasets relevant to Singapore population were explored for the project. The datasets required for this analysis were imported to Jupyter Notebook and explored using Python programming language. The analysis was conducted on annual data for a predefined time period. Certain demographics and healthcare utilization parameters were used to develop the patient profile, health state transitions and their corresponding utilization.

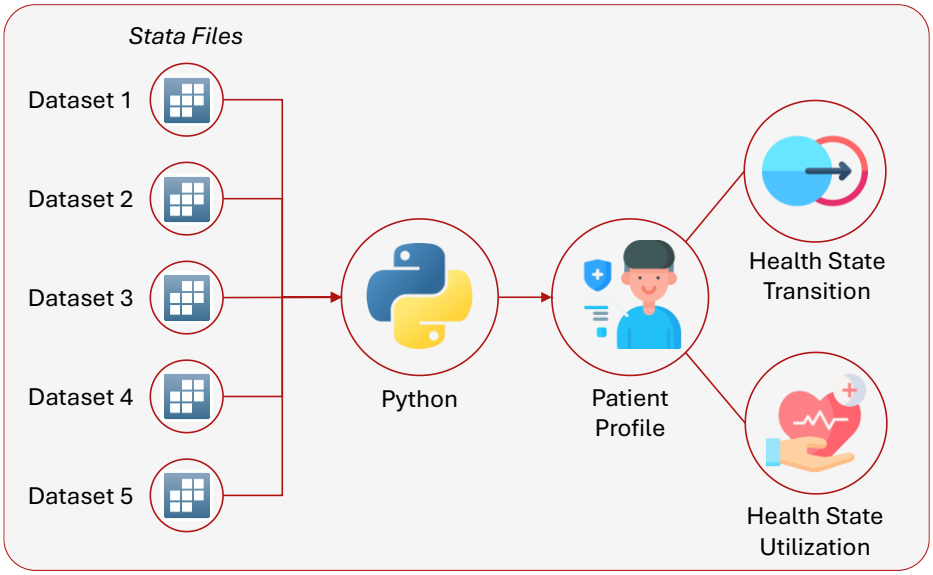

Figure 1: Data Exploration and Patient Profiling

2.3. The Developed Model

The development of the system dynamics model was architected using Python programming language in a modular manner so that a team of analysts can simultaneously work, update, and in future own different modules. The model was into self-contained modules.

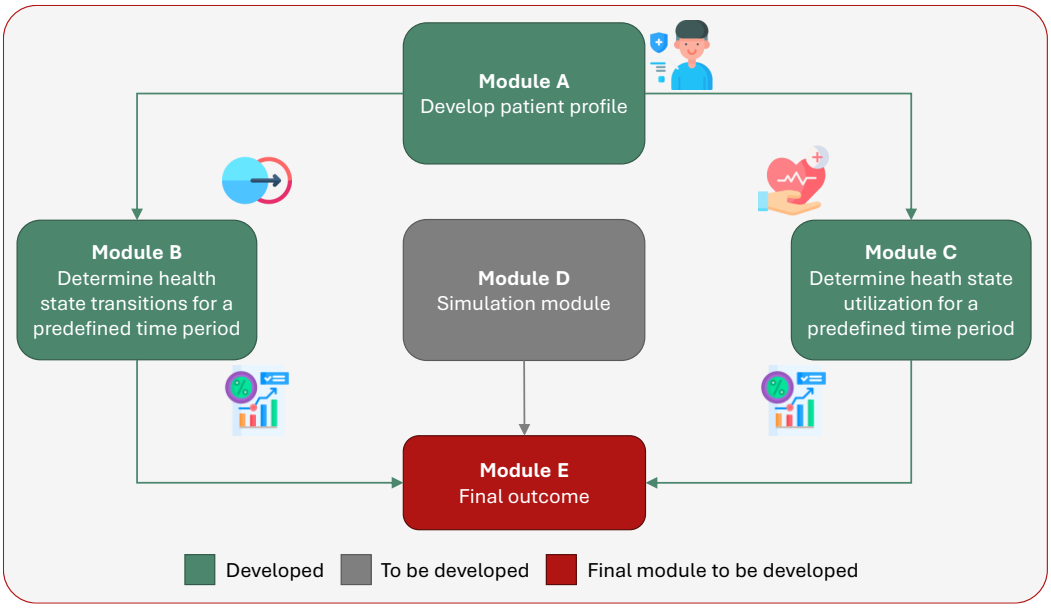

Figure 2: Simplified Representation of Modules of the Systems Dynamic Model

1. **Module A** – This module filters and merges datasets to develop sample profiles. The profiles are based on demographic characteristics and healthcare utilization parameters for a predefined time period. The module then segments sample profiles into health states based on parameters critical in evaluating chronic disease conditions.

   As an illustration, see below the segmentation for Enhanced Primary Care Services for Older Adults in Singapore. The model splits the population into health states based on demographic characteristics such as age and gender and features that complicate

chronic conditions (Matchar, 2021). Similar approach was used to segment profiles in the Systems Dynamic model.

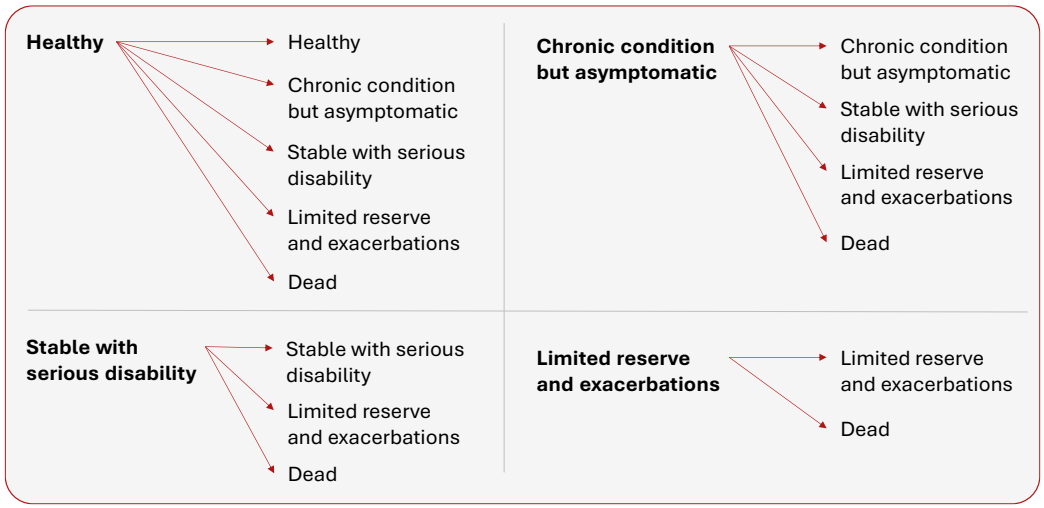

Figure 3: Representation of Health State Transitions (Matchar, 2021)

2. **Module B** – This module determines transition of population into different health states for a predefined time period. The module also highlights gaps that may exist between in transition into different health states.

3. **Module C** – This module determines utilization of healthcare services by population in different health states for a predefined time period. The module also highlights gaps that may exist in the utilization of healthcare services by the sample population.

4. **Module D** – This module includes simulators of Healthier SG to assess the impact on population health states, population transition, and their utilization of healthcare services.

   As an illustration, see below the simulation model for Enhanced Primary Care Services for Older Adults in Singapore. The model built by Duke-NUS takes various parameters as inputs – system outputs, patient and provider preferences, policy options, epidemiology of needs, effects of options - whose impact will be assessed on transition of population into different health states and their corresponding healthcare system utilization.

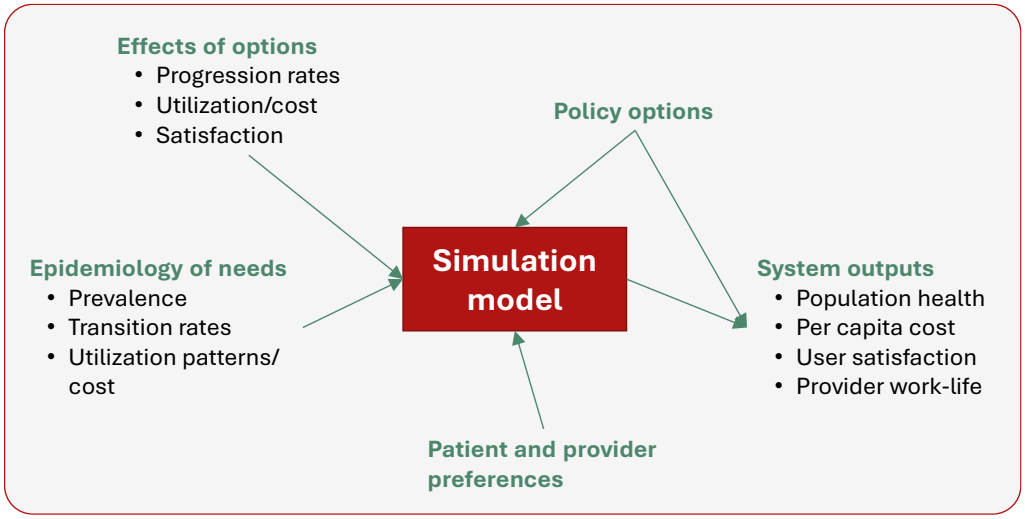

Figure 4: Representation of the Simulation Module (Matchar, 2021)

5. **Module E** – This module is a cumulation of the rest of the modules of the model. After overlaying the Simulation Module and taking inputs from Module B and Module C, this module will visualize the impact of Healthier SG on Singapore's healthcare system. The module can also help quantify and track the success of Healthier SG initiative in the years to come.

2.4. Result

The model can efficiently calculate and project population transition into different health states and the corresponding healthcare service utilization up to 2040, and forms the backbone for the team as the team can include other parameters in the model based on future scope development. This will help with simulation as the baseline parameters are calculated and validated against administrative data and national surveys conducted by MOH. For instance, Healthier SG will encourage Singaporeans to undergo regular health screening for conditions such as diabetes, hypertension, and hyperlipidaemia. Increased screening will make the population more aware of their health conditions and take better preventive healthcare measures. Preventive care will, in turn, lower healthcare cost in the long run, reduce the burden on the family, and make healthcare more sustainable for the nation. Chronic disease screening parameter when included in model can eventually help simulate decrease in healthcare cost in the future (Khalik, Salma, 2022).

The model will thus be imperative for policy making decisions, such as resource planning. Resource planning entails identifying how healthcare demand would change in the future and healthcare settings in which supply shortage would be expected, and correspondingly take measures to meet the supply gap by ramping up infrastructure and manpower to meet the demand. The model also forms the foundation for future iterations as the same framework can be used to simulate other kinds of policy interventions.

Given the parameterized and modularized format of the developed model, it can be seamlessly tailored to accommodate the expanding scope of the project. For example, if the team decides to change the resident segmentation criteria in the future to better suit the requirements, minimal code changes are required. New modules can be overlayed to the existing modules, alleviating the need for remodelling from scratch. The projection time period and scope of diseases can also be expanded with minute changes to defined parameters.

3. Application of MITB Coursework

3.1. Python Programming and Data Analysis

The systems dynamic model that currently segments sample population, determines health state transition and utilization, and forms the foundation to simulate and assess the impact of Healthier SG in the future has been entirely developed using Python Programming. This course laid a strong foundation by expansively covering use of classes and functions that helped in developing the model in a modular fashion and packages including NumPy, Pandas, Stats from SciPy essential for manipulating data, segmenting Singapore population by different health states, and calculating transition rates and utilization over the years.

3.2. Data Analytics Lab

The learnings from this course helped me to study and understand the data before exploration, perform segmentation, and draft detailed change log and documentation imperative for handover post internship completion. The comprehensive approach of this

course – data study, data exploration, data manipulation, population segmentation, data analysis, research and evidence backed insight generation, change log management, and detailed documentation have been used in every step of the model development.

3.3. Data Science for Business

This course gave me an overall picture of all the business problems that can be solved using Data Science and study gaps that may exist between the data and real-world business. For instance, to cover the gap between the sample population and original Singapore population, I defined functions to select 'new entrants' in the model based on logical conditions such as year of birth of the entrant to be less than the year of selection, resident status to be Singapore citizen or permanent resident, and age lower than 113 years.

3.4. Applied Healthcare Analytics

This course helped me understand the key elements that make up the analytics value chain for healthcare, achieve a good understanding of the potential and limitations of the data analytics solutions in the healthcare system, apply descriptive, predictive and prescriptive analytical techniques to deliver value in the healthcare system, understand the key problems and challenges in the use of data and data analytical methods to derive full value from data resources and relate data science results to healthcare outcomes and business in the healthcare system.

4. Reflections

The internship experience with the Data Analytics Division at MOH was an immersive and informative experience. The end-to-end process of scoping the project, studying white papers to develop understanding of systems dynamic model, brainstorming with subject matter experts (SME) on the segmentation approach, project execution planning, data analysis, pair programming, and creating a feedback loop with pertinent stakeholders were important learnings gained through the internship. Some of my takeaways from the internship are –

4.1. Technical takeaways

- Develop a Minimum Viable Product (MVP) for the users to get a first experience of the product. It enables a feedback and continuous improvement loop.
- Pair programming helps to speed up the process and helps both developers to gain understanding of each other's style of programming
- Parameterize variables to make it easy to expand the scope of the model – for example, increase number of chronic diseases to assess Healthier SG impact, expand the number of years for projection etc.
- Modularize to enable simultaneous ownership, programming, and update of the model by a team of analysts
- Maintain change log, progress files, and documentation for efficient handover to succeeding analysts/model developers
- Address the anomalies and the gaps in the program outcome and data through secondary research and SME opinions and insights

4.2. Non-technical takeaways

- Be proactive about updating the leadership and relevant stakeholders about the progress of the project and incorporating their feedback. This helps build confidence in both the project and one's capabilities to deliver milestones in time.
- Liaise with SMEs and specialist third parties to improve model inputs, and the outcome
- Keep communication lines clear with third parties by recording minutes of the meeting and sharing the same with all the stakeholders of the project. This will alleviate any misunderstandings or miscommunication
- Seek help when facing roadblocks in time. This can help with damage control and manage project timelines and milestones
- Networking and maintaining good relationship with member of one's team and other teams will help one learn from their experience and tacit knowledge. This way one can prevent reinventing the wheel and find the right point of contacts in the organization pertinent to the project and better manage time, efforts, and resources

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