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Modeling the Affordability of Cancer Drug Expenditures in Hong Kong Public Healthcare System: A System Dynamics Analysis

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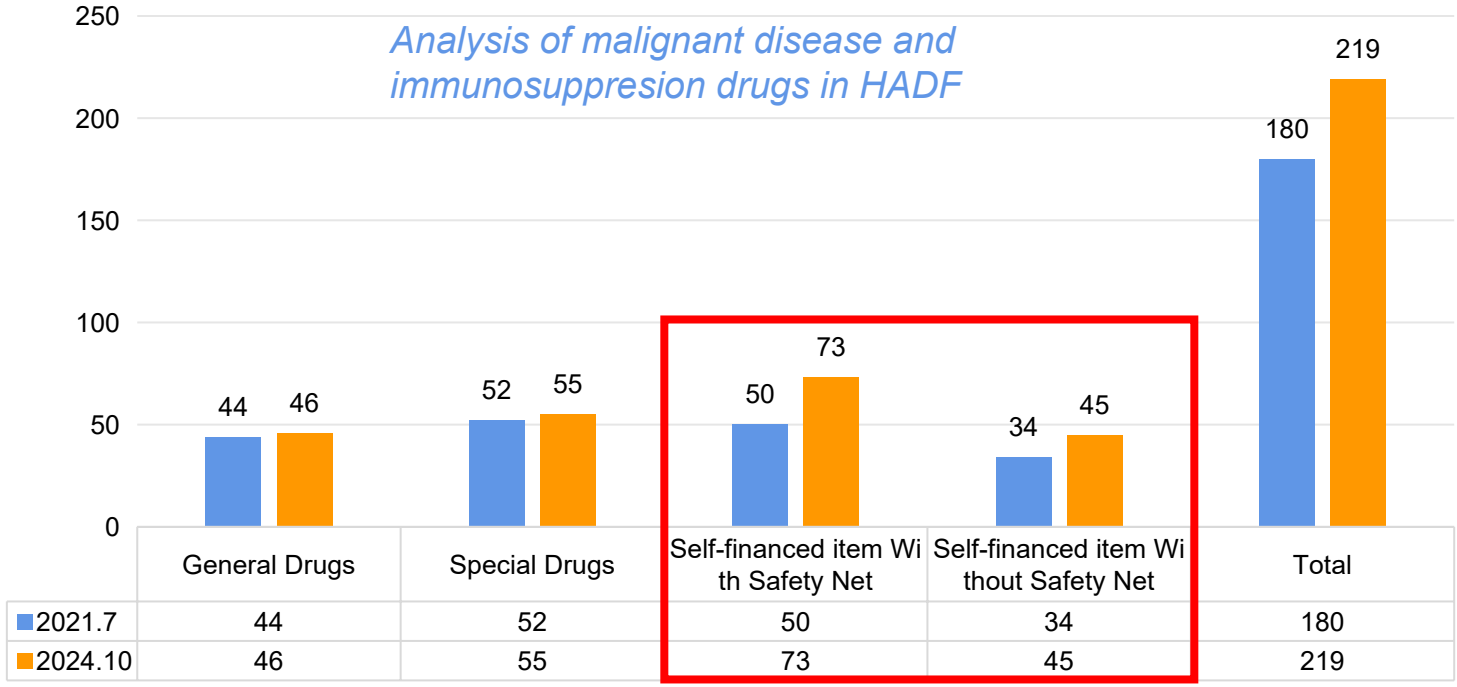
Background

Thesis topic: *Improving access to cancer drugs in Hong Kong: Evidence from a systematic policy review, stakeholder in-depth interviews and policy simulation*

Methodology	*Outputs*	*Stages heuristic*
Phase I: Policy review	➢ A policy review with document analysis on issues of HK pharmaceutical policy, and policy responses from the government.	Problem identification and issue recognition
Phase II: In-depth Interviews	➢ Barriers and facilitators of effective implementation of policies on improving access to innovative cancer treatments.	Policy implementation
Phase III: Policy simulation	➢ ***Develop a system dynamics model to predict the financial impact of cancer drug expenditure on the public healthcare system, and to simulate the effects of policy interventions on the affordability of patients and the system***	Policy evaluation

Key findings of previous qualitative studies:

- Despite efforts to ensure that new cancer drugs are available in the market, ***affordability*** remains a critical barrier that prevents many patients from accessing these treatments.
- A significant gap in the affordability of self-financed drugs: While safety net programs provide some financial relief for low-income patients, many others—particularly **middle-class patients** *without commercial health insurance* and those who *fail the asset assessment for safety net eligibility*—***do not receive any government financial support***.



Source: analysis by the author

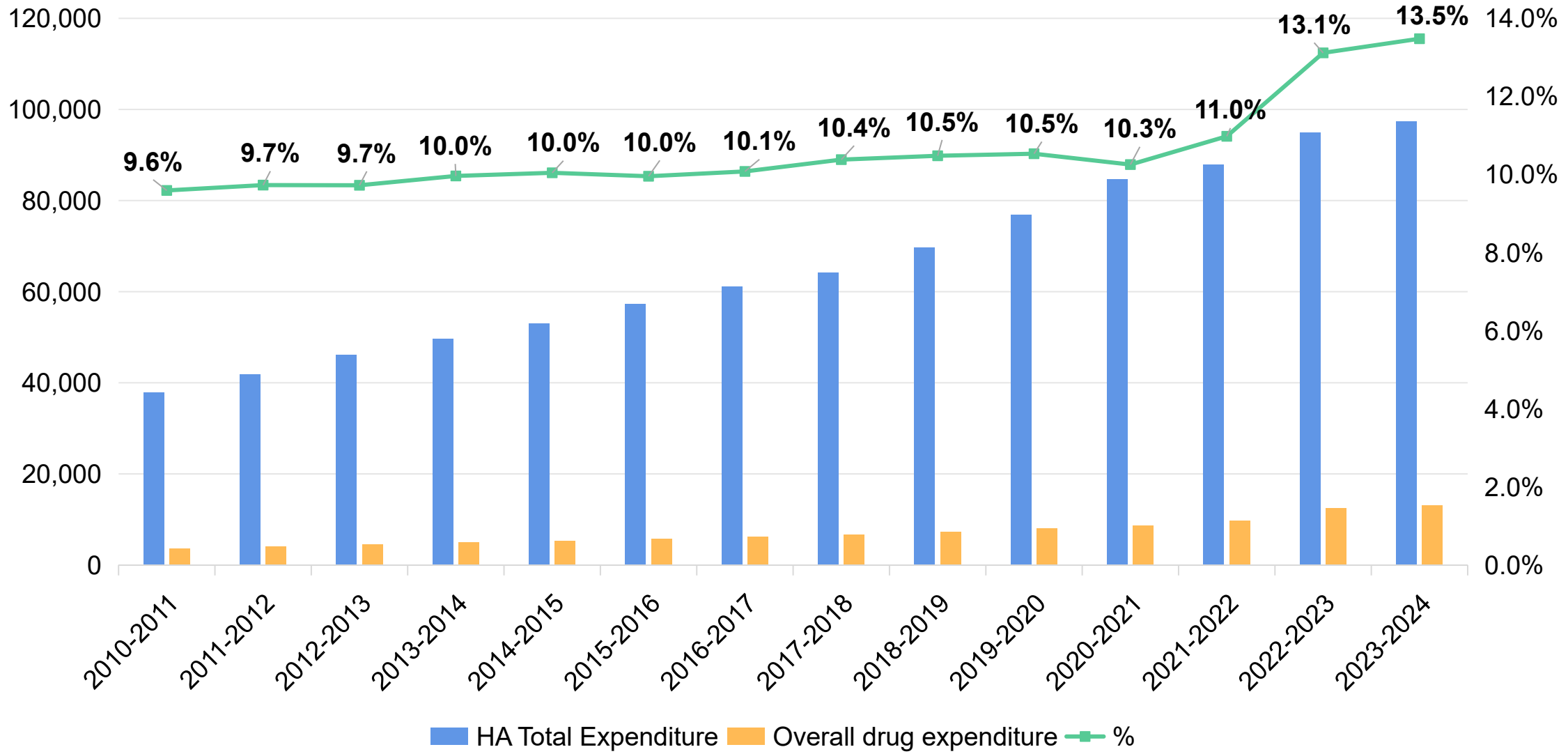
Government's pathways to improve the affordability for cancer patients:

- In the long term, to increase **market competition** by reforming drug **registration policy** to introduce more cancer drugs with cost-effectiveness, couple with strengthening local drug **R&D capacity**, which can **potentially** lower the drug price.
- In the short term, to proactively conduct **price negotiation**, incentivise **medical insurance (VHIS)** and provide **safety net** for eligible patients.

Based on the affordability gap for middle-class patients, many stakeholders suggest developing a **co-payment** mechanism. However, the opinions towards operation of copayment have been diversed:

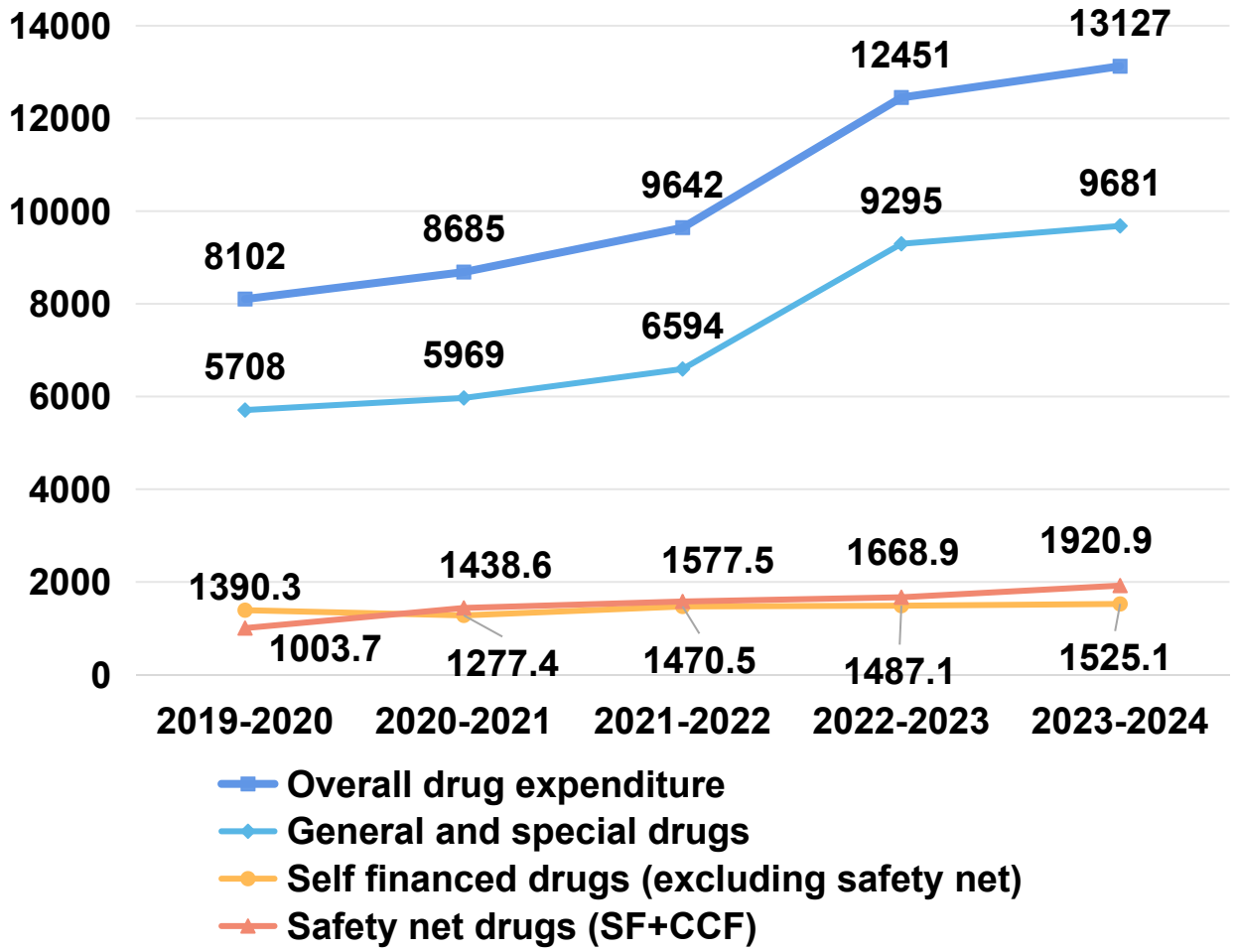
Copayment Proposal	Proposal Explained
Insurance Copayment Mechanism *By Participant 1, Former HA Chief Pharmacist*	A cost-sharing model involving government subsidies, pharmaceutical discounts, and patient contributions, integrated with incentivized commercial insurance to reduce premiums and ensure long-term affordability of cancer drugs.
Medical Savings Account *By Participant 15, Academia in Health Financing*	A salary-deduction scheme (1-2%) for a medical savings account, enabling middle-class patients to copay for enhanced services (e.g., shorter wait times) while reducing government subsidies from 90% to 50%.
Social Medical Insurance *By Participant 9, Former Cluster Chief Executive*	A flexible government-run insurance where patients contribute scaled copayments for cancer drugs, subsidized by the government, akin to Thailand/Indonesia's universal health coverage but tailored for Hong Kong's middle-income demographics.
Dedicated Cancer Fund *By Participant 4, Patient Group Leader*	A government-managed, multi-source fund combining drug price reductions, means-tested patient contributions (10-20%), and public crowdfunding to subsidize cancer treatments for near-poor patients excluded from full subsidies.

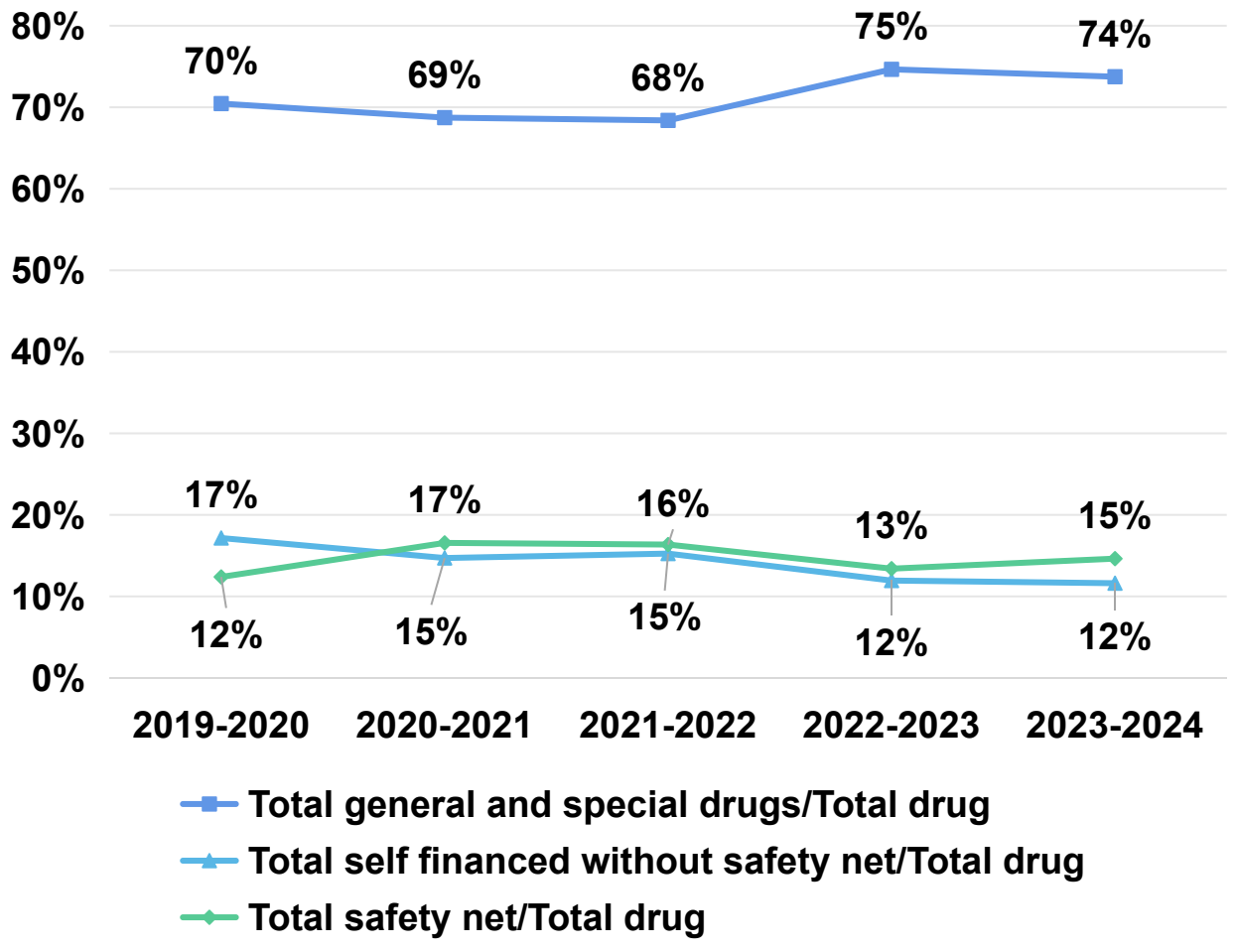
Drug Expenditure and its percentage to HA Total Expenditure



Drug Expenditure and its Components

Unit: Million (HKD)



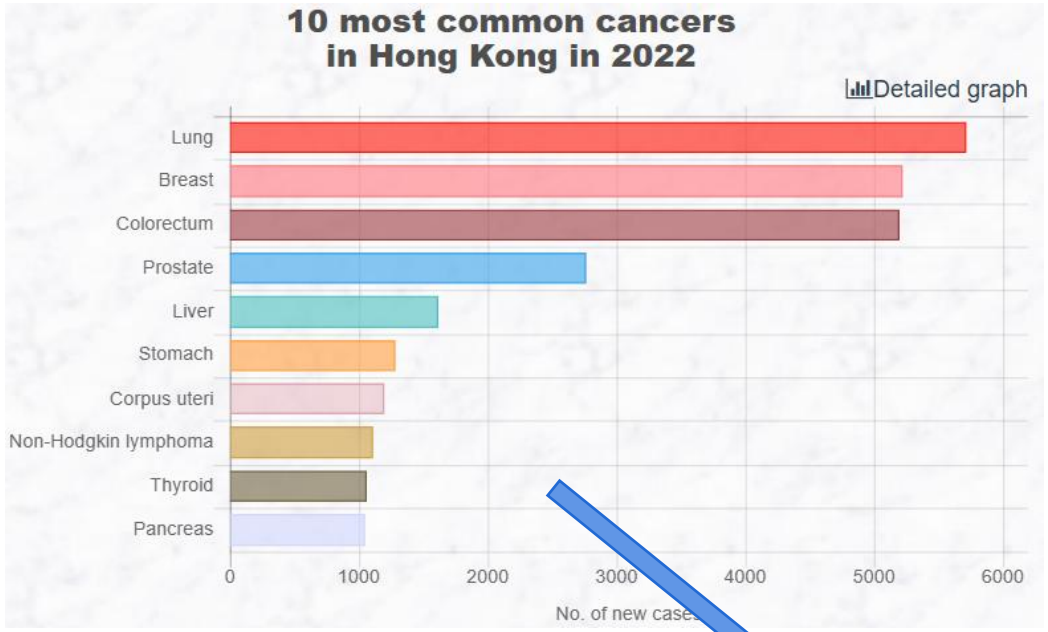


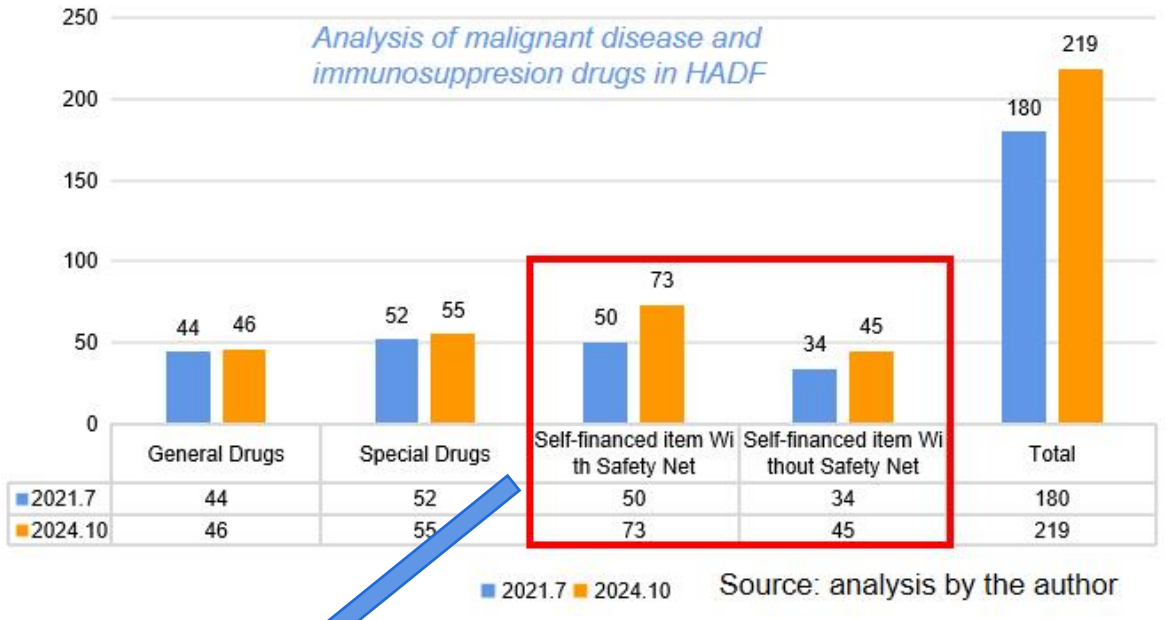
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Data source: Legco

Breakdown of self-financed cancer drugs





Self-financed Drug Type for Top 10 Cancers	n	%
Targeted therapy	41	75%
Immunotherapy	8	15%
Chemotherapy	6	11%
Overall	55	100%

Souce: analysis by the author

Research Aim

- **Research gap:** Limited evidence estimating the cancer drugs cost and evaluating the effectiveness of current policies in Hong Kong.

- **Research questions to be answered**:

➢ What is the current cost pattern and financial burden of cancer drugs within the Hospital Authority Drug Formulary (HADF)?

➢ How might demographic trends, such as an aging population and rising cancer incidence, affect long-term drug affordability under current policies?

➢ How might proposed policy interventions affect affordability?

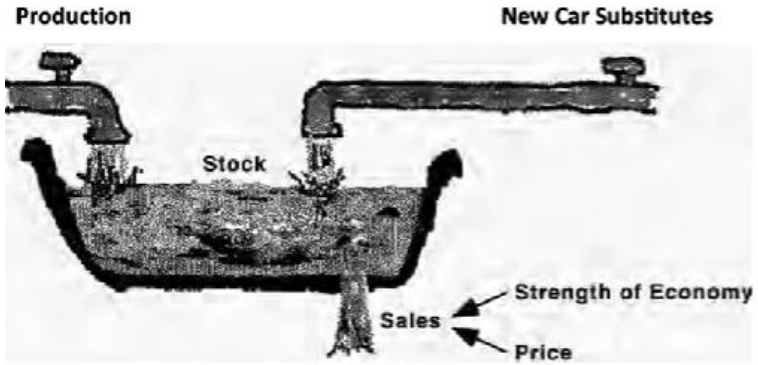
- The aim of the study is **to analyze the long-term affordability of cancer drug expenditures under Hong Kong's current public healthcare financing mechanism, using a system dynamics model that integrates macroeconomic factors, demographic pressures, and cost dynamics within HADF (2023-2040).**

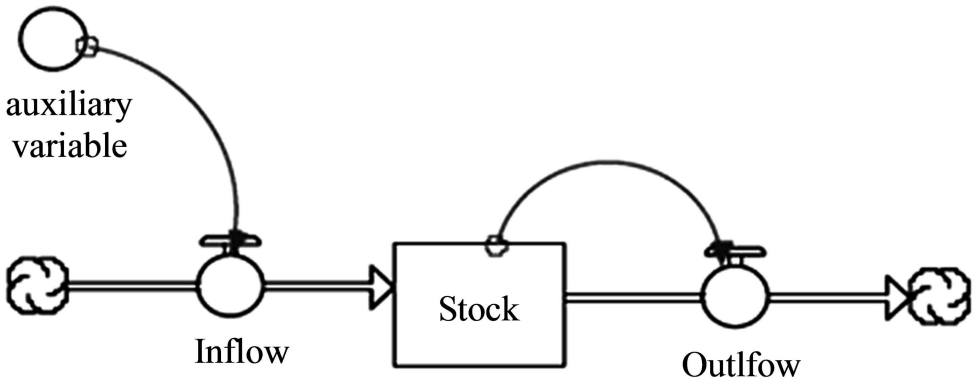
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Methodology

“The Bathtub Analogy” of System Dynamics (SD): Stocks and Flow Diagram



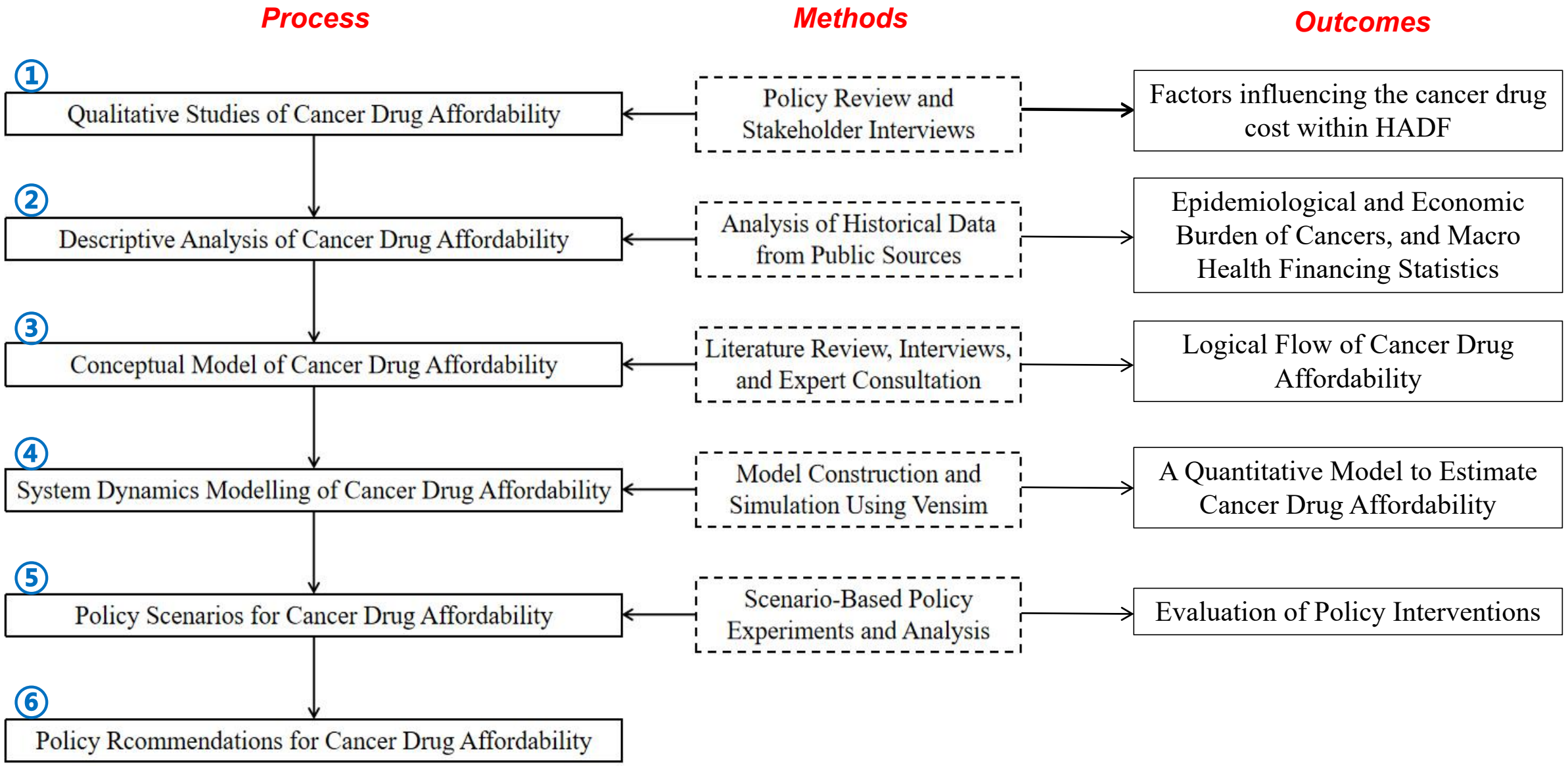


Software: Vensim® PLE

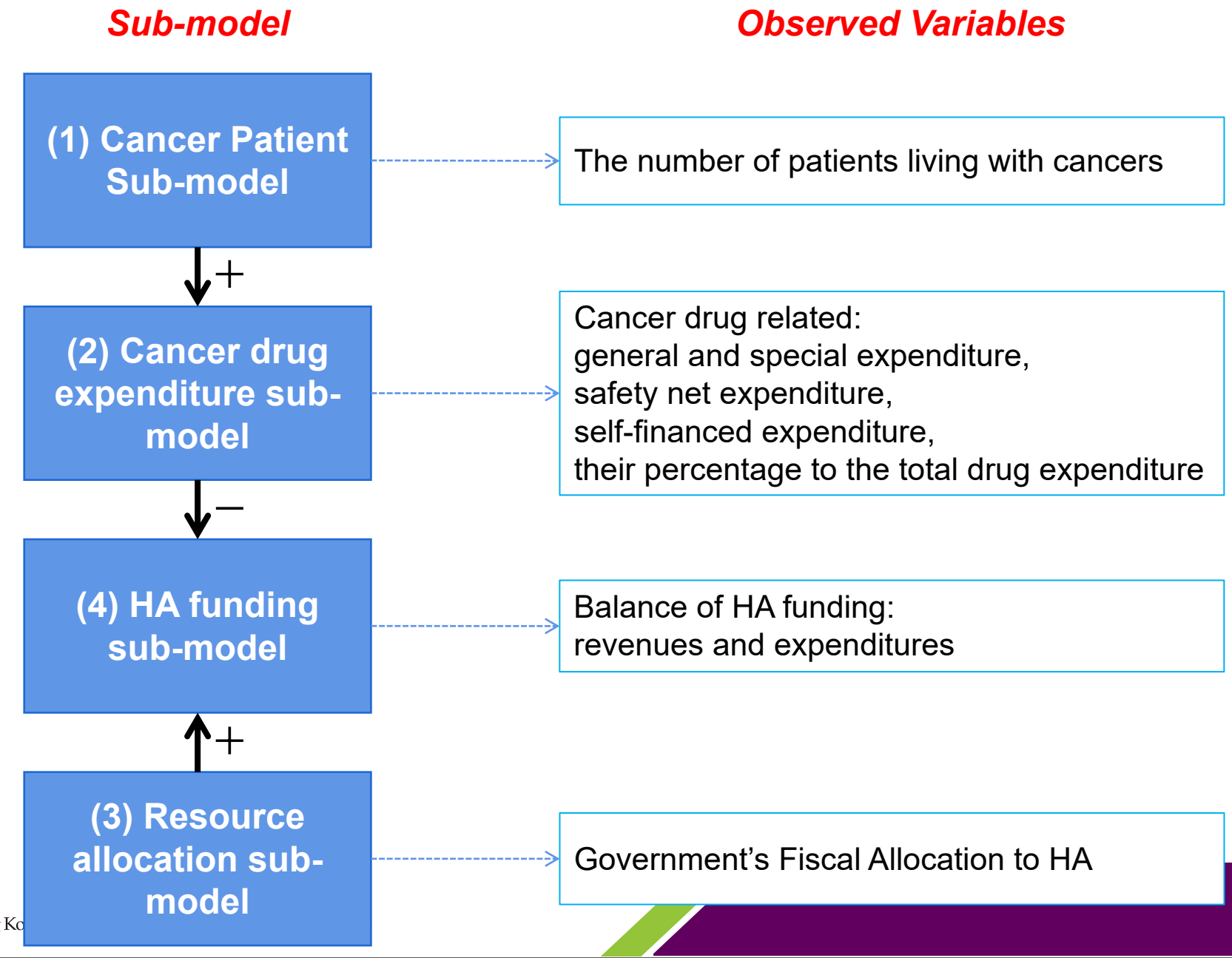
- The SD approach is a **macro-level modelling** methodology, which is capable of analysing complex and nonlinear problems.
- The philosophy of the SD model is to **explain the effect of short-term strategies and policies**, and estimate the **time-dependent behaviour** of a complex system based on *qualitative and quantitative historical data*.
- **Stock and flow diagrams** is a modelling method used to illustrate the behaviour of an investigated system.
- **Stock** represents inflow and out-flow processes, and **flows** are the ratios of the inflow and outflow of the stock variables.

✓ Enables "what-if" scenario testing for policy simulation.

Procedures of Constructing a System Dynamics Model

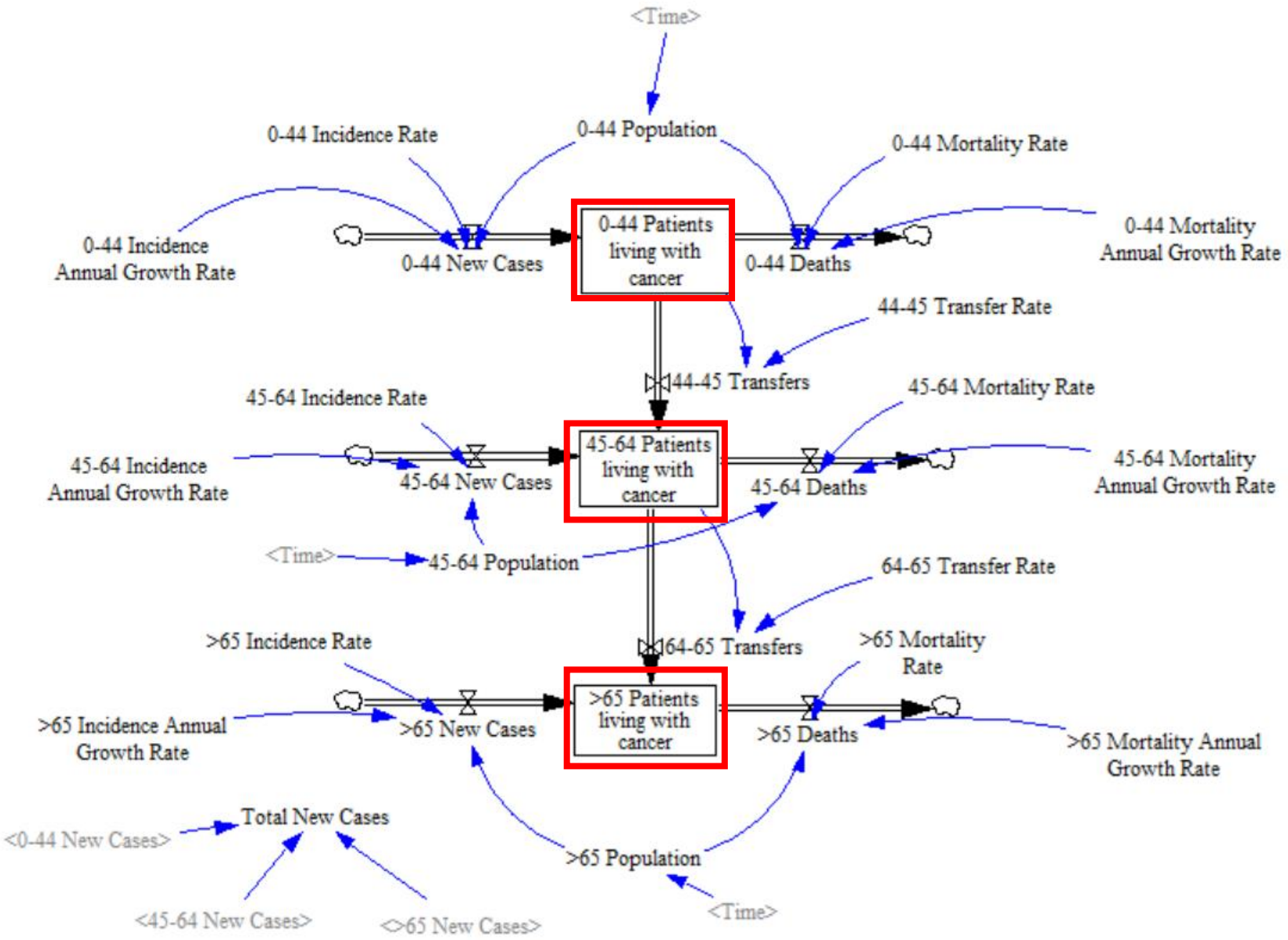


Step ③: Establishment of a Conceptual Model and Observed Variables

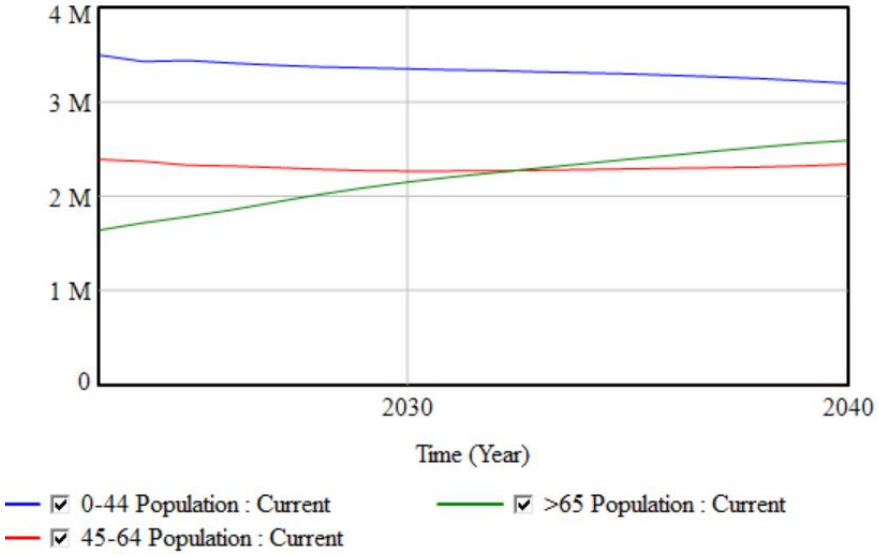


Step ④: Establishment of a Stock and Flow Diagram

(1) Cancer Patient Sub-model

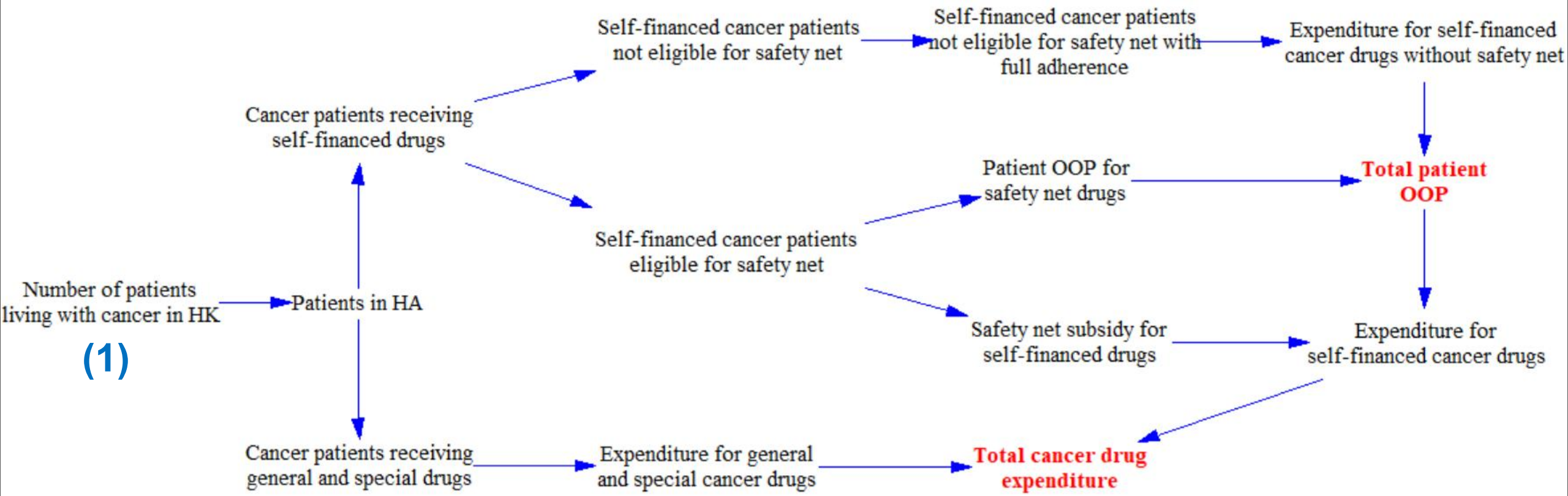


Population is input as table variables estimated by HK government:



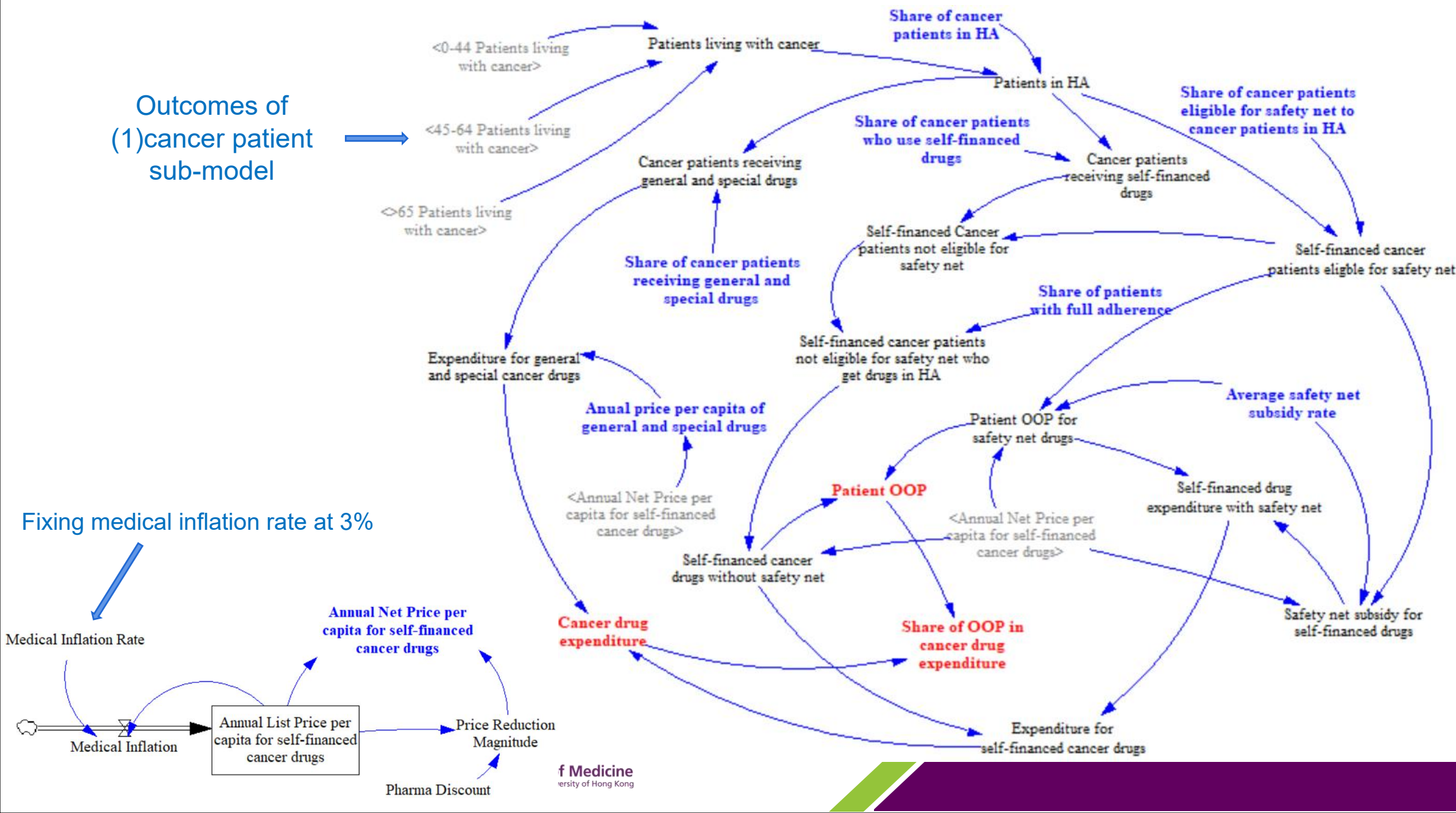
Data source:
Hong Kong Cancer Registry Database
Census and Statistics Department, HKSAR

(2) Conceptual Workflow of Cancer drug expenditure sub-model



(2) Stock and Flow Diagram of Cancer drug expenditure sub-model

Outcomes of (1)cancer patient sub-model



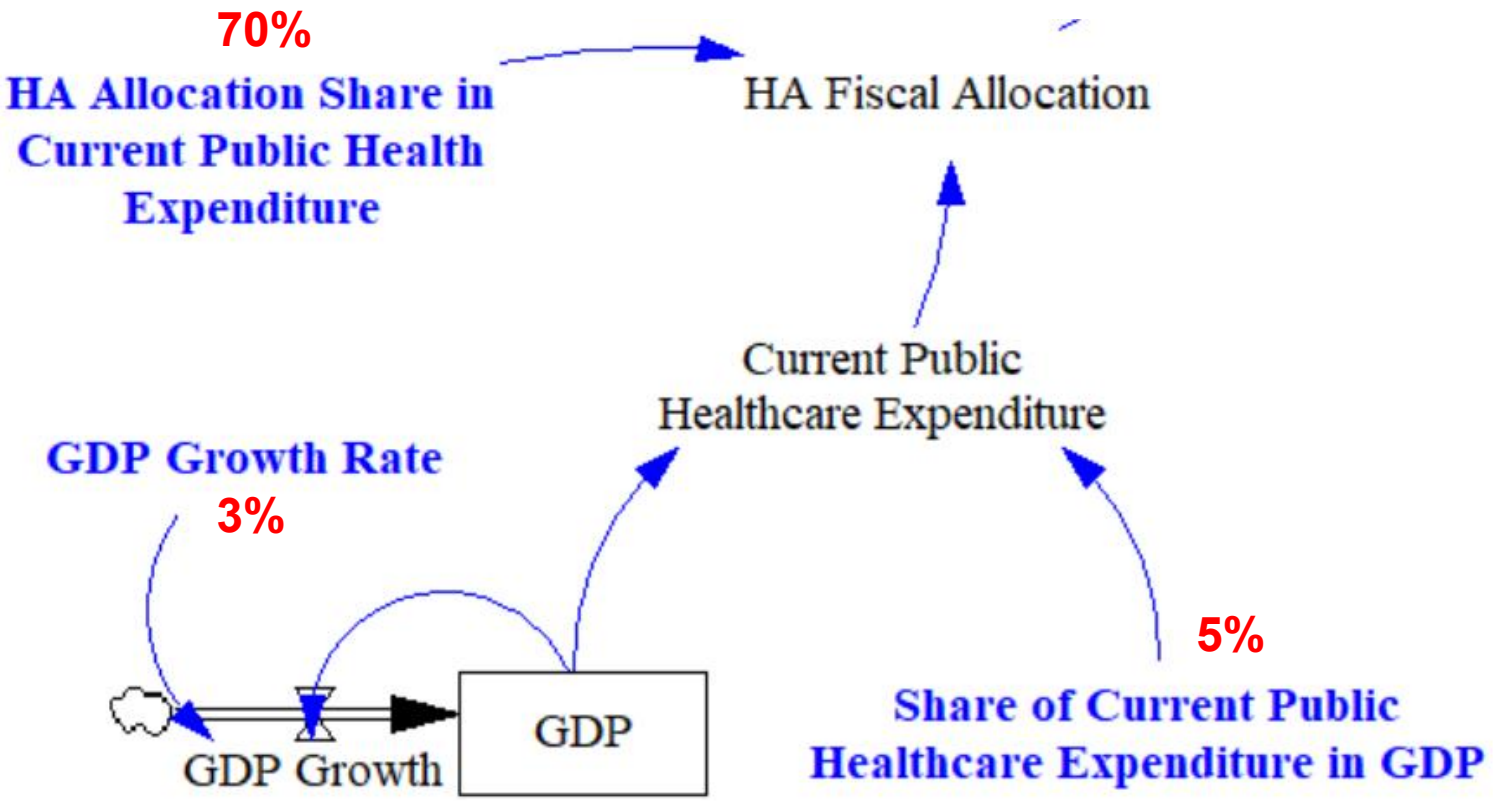
Fixing medical inflation rate at 3%

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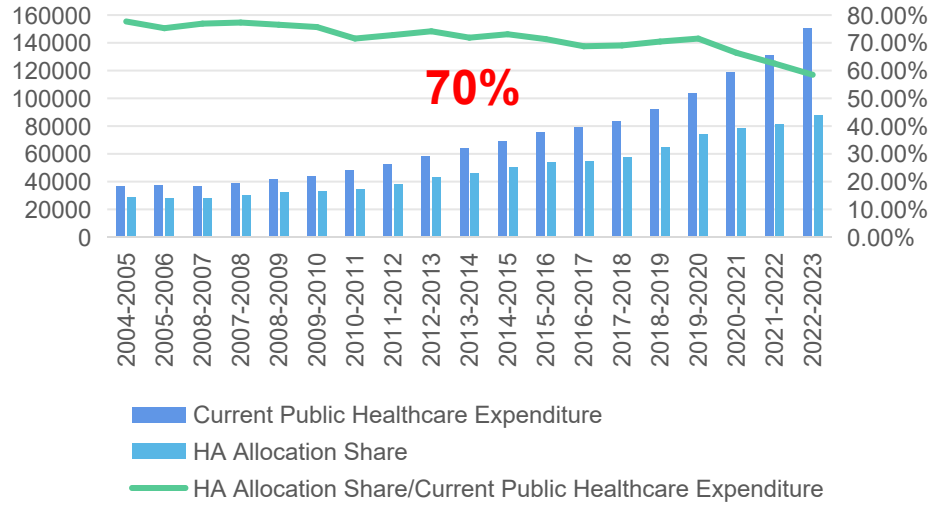
Estimates of parameters as constant variables in cancer drug expenditure sub-model

Constant Variables	Value	Source
Share of cancer patients in HA	90%	"the HA, at which nearly **90%** of new cancer patients had attended in Hong Kong within the first six months of cancer diagnosis"-*Hong Kong Cancer Strategy 2019 - Health Bureau*
Share of cancer patients receiving general and special drugs	95%	Expert input-around the usage rate of chemotherapies
Share of cancer patients who use self-financed drugs	20%	Expert input-around the usage rate of targeted drugs
Share of cancer patients eligible for safety net	3.5%	Estimate from the presentation of Secretary for Health
Share of patients with full adherence	3/5	Estimate from the presentation of Secretary for Health and the news attended by chief executive of HA
Average safety net subsidy rate for eligible patients	80%	Estimate from the eligibility criteria published by HA
Anual price per capita of general and special drugs	1/30 of self-financed drugs	Expert input and estimate from the LegCo material
Anual price per capita of self-financed drugs	150,000 HKD	Estimate from the presentation of Secretary for Health

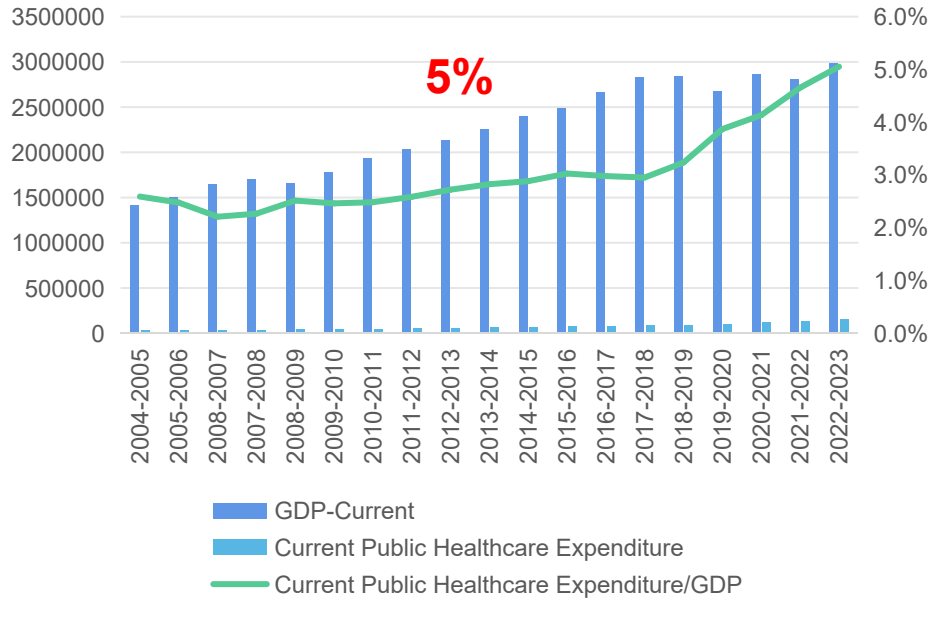
(3) Stock and Flow Diagram of Resource allocation sub-model



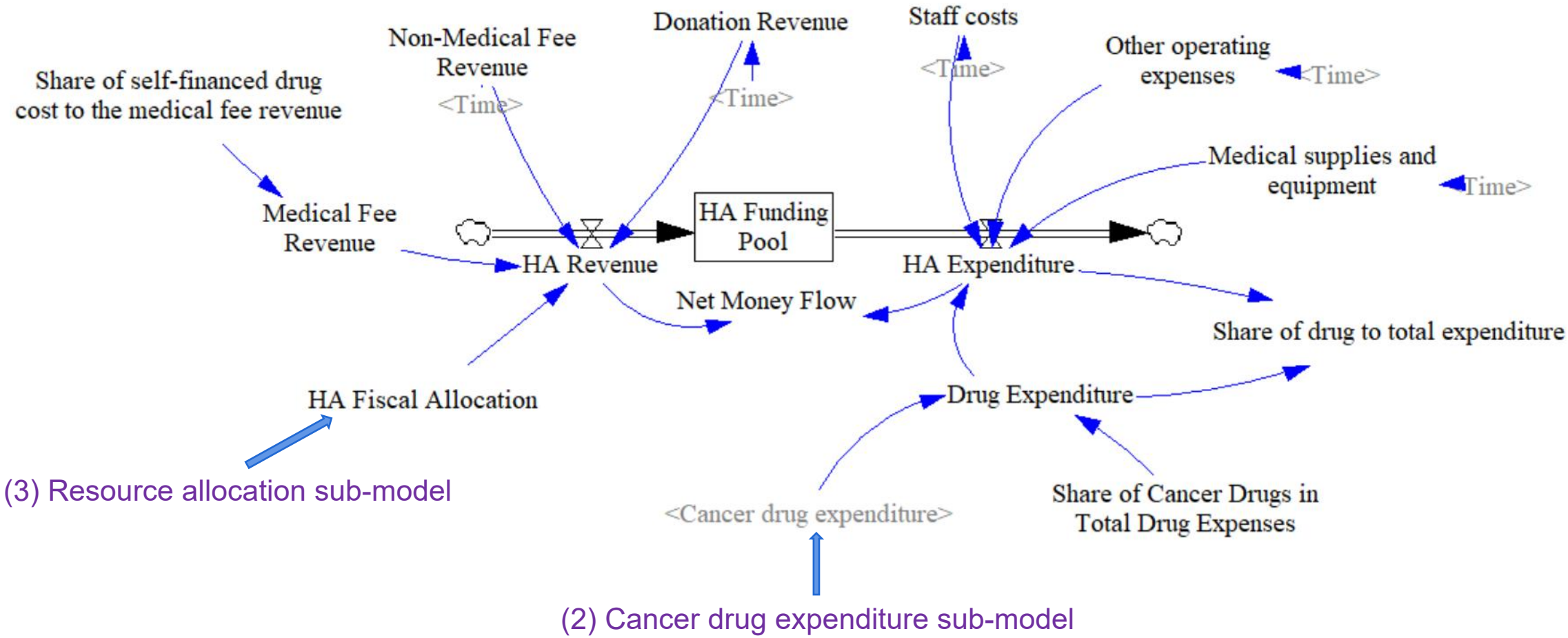
HA Allocation Share/Current Public Healthcare Expenditure



Current Public Healthcare Expenditure/GDP



(4) Stock and Flow Diagram of HA funding sub-model



Notes:

- Only **expenditures for general and special drugs** are accounted for in **HA funding**, as **expenditures for self-financed drugs**, covered by patients or the safety net, **are redirected to medical fee revenue**.
- **Other revenues and expenditures** (e.g., non-medical fees, donations, staff costs, medical supplies, equipment, and other operating expenses) are modeled as **constant variables**, with their growth rates estimated based on historical data and assumed to increase at a **steady rate**.

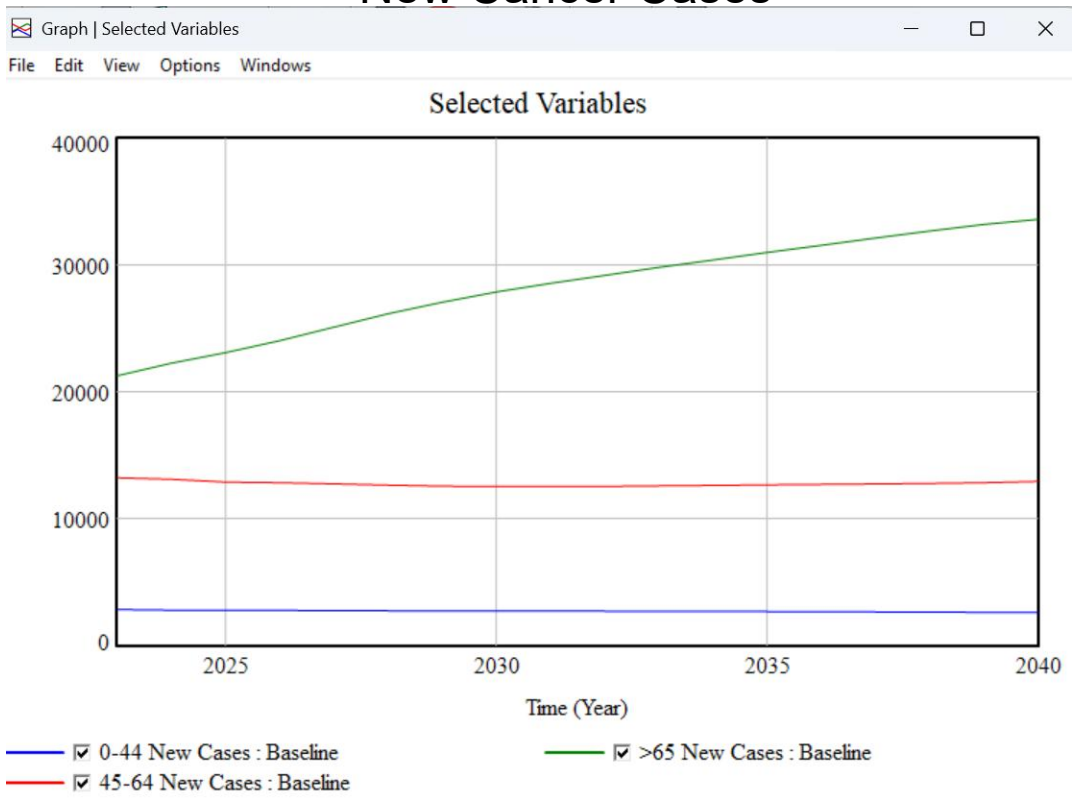
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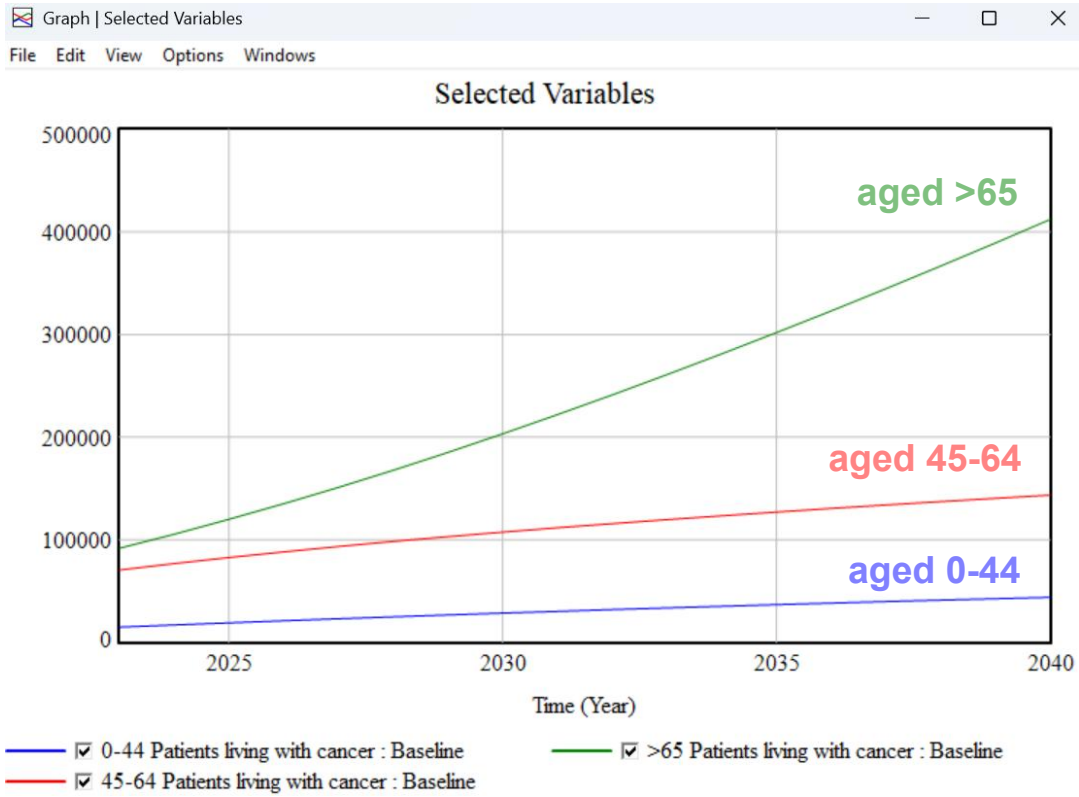
Results and findings

(1) Cancer patients modelling

New Cancer Cases



Patients living with cancer



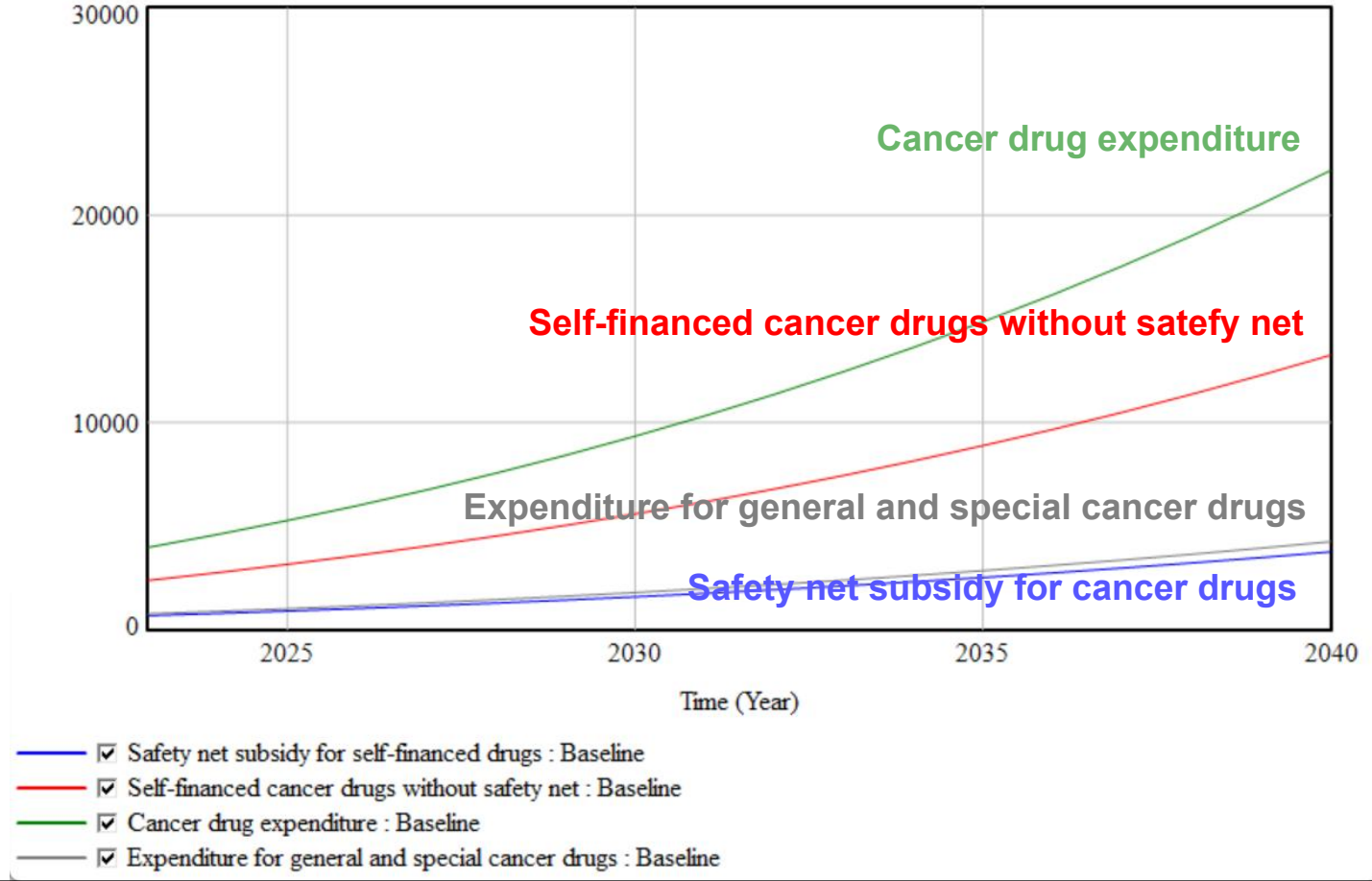
Comparison of Simulated Results with Another Predict Data

Variable	Simulation	Prediction by the authority	Error rate
New Cancer Cases in 2030	42366	43000	8.6%

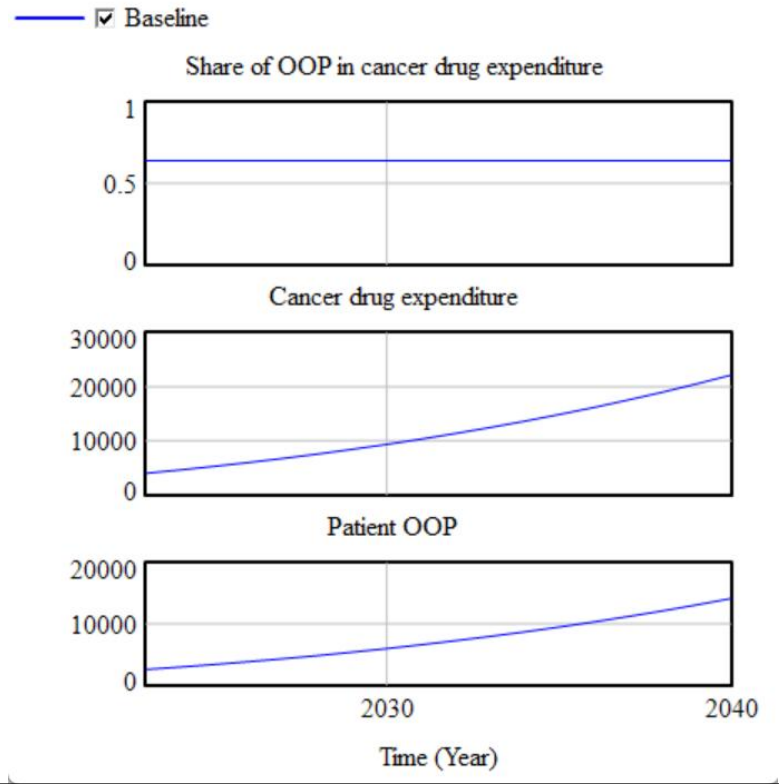
(2) Cancer drug expenditure modelling

Unit: Million HKD

Time (Year)	2023	2024	...	2039	2040
Self-financed cancer drugs without safety net	1116	1255	...	3605	3777
Expenditure for general and special cancer drugs	957	1076	...	3090	3238
Safety net subsidy for self-financed drugs	298	335	...	961	1007
Cancer drug expenditure	2445	2750	...	7897	8274

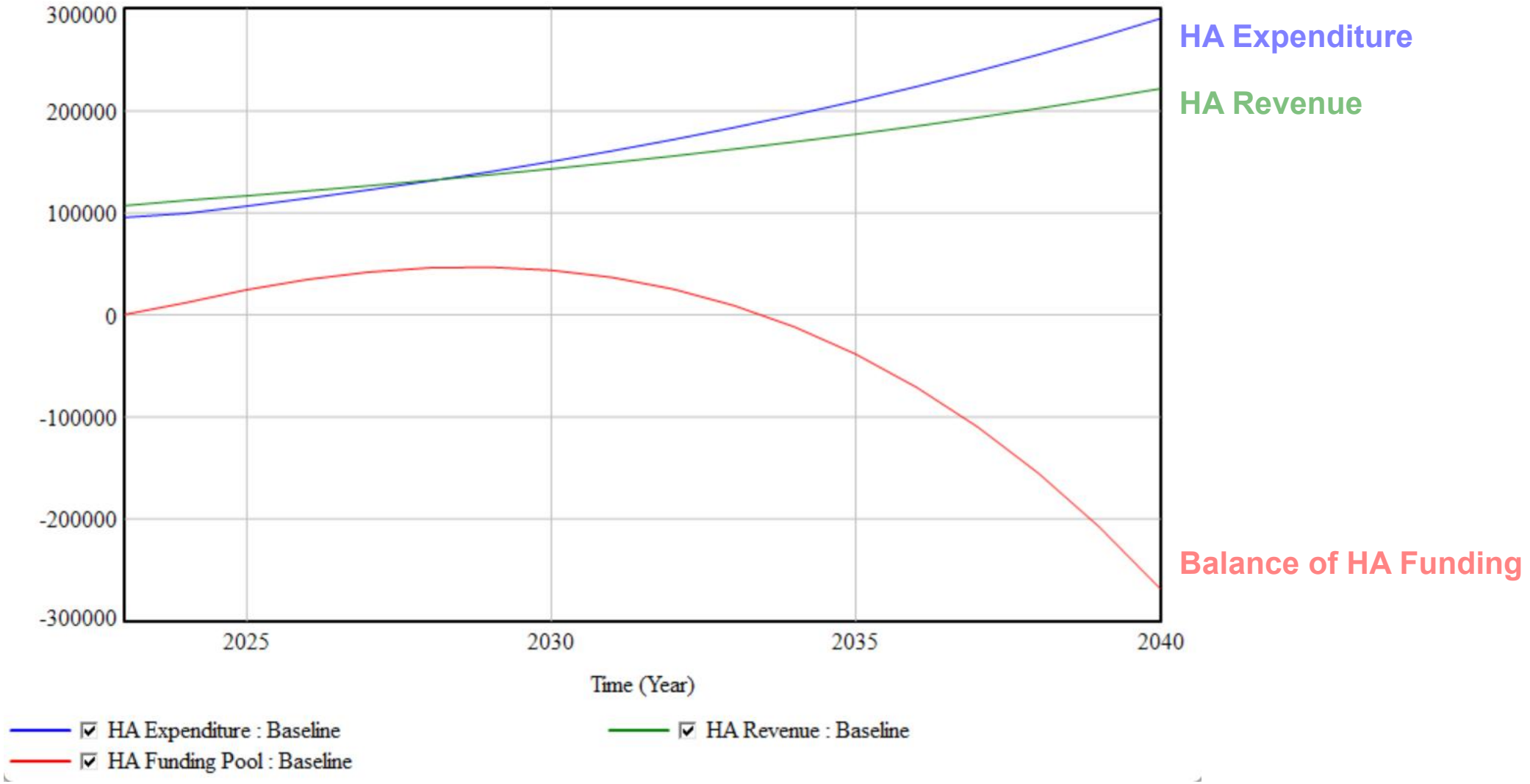


Share of OOP in cancer drug expenditure: **64%**



(4) HA funding pool modelling

Time (Year)	2023	2024	...	2033	2034	...	2040
HA Funding Pool : Baseline	491	12002.3	...	9278.23	-11881.8	...	-268358



HA Expenditure

HA Revenue

Balance of HA Funding

Key findings of baseline analysis

1. Model Validation and Accuracy

- Baseline projections aligned closely with real-world data:

✓ Simulated new cancer cases in 2030: 42,366 (vs. government prediction of 43,000), with an **error rate of 8.6% (deemed appropriate if the error rate is less than 15%)**.

✓ Simulated total drug expenditure in 2023: 12,226 million HKD (vs. actual 12,451 million HKD), with a **1.8% error rate**.

✓ Simulated drug expenditure in 2024: 13,127 million HKD (vs. projected 13,750 million HKD), with a **-4.7% error rate.**

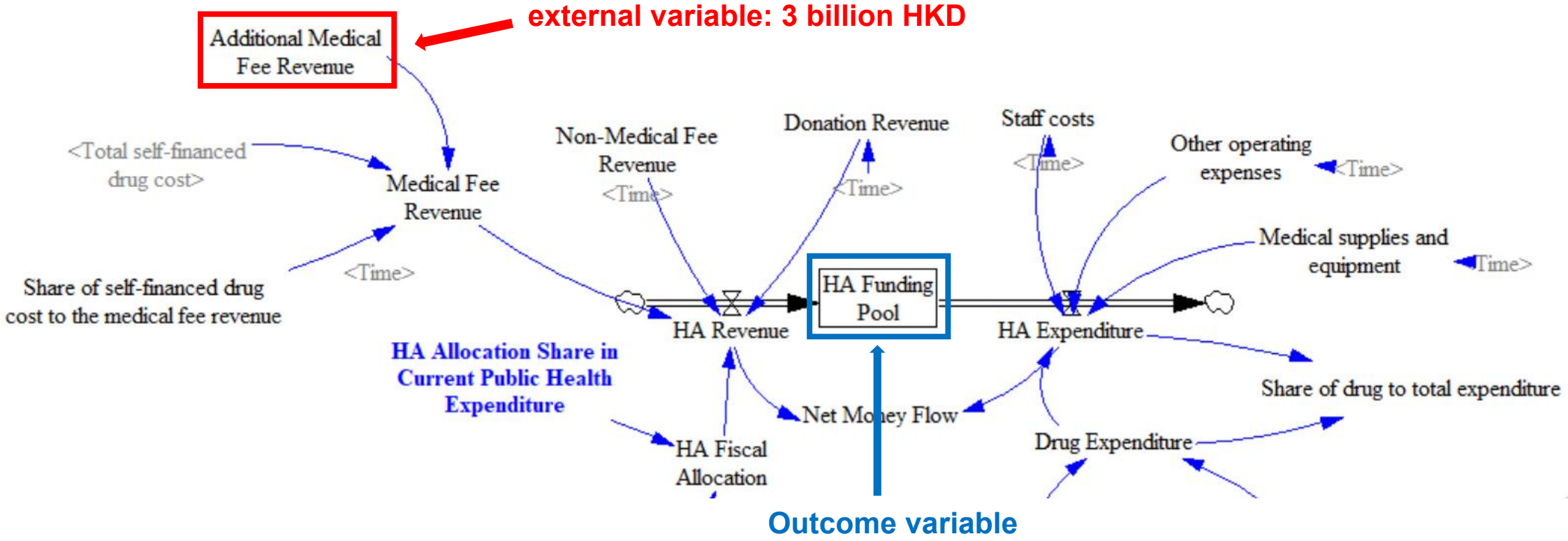
- These results validate the model's reliability for policy simulations.

2. Key findings:

- **Out-of-pocket (OOP) spending accounts for 64%** of total cancer drug expenditure, highlighting severe economic burden for patients not covered by safety nets.
- The **current public healthcare financing system**, which predominantly depends on government fiscal allocation, **is unsustainable**, with the model projecting a depletion of resources by approximately 2034.
- Public subsidies struggle to keep pace with rising costs, risking reduced access to newer therapies for low-income and middle-class patients, **calling for multiple financing for self-financed drugs in HA**.

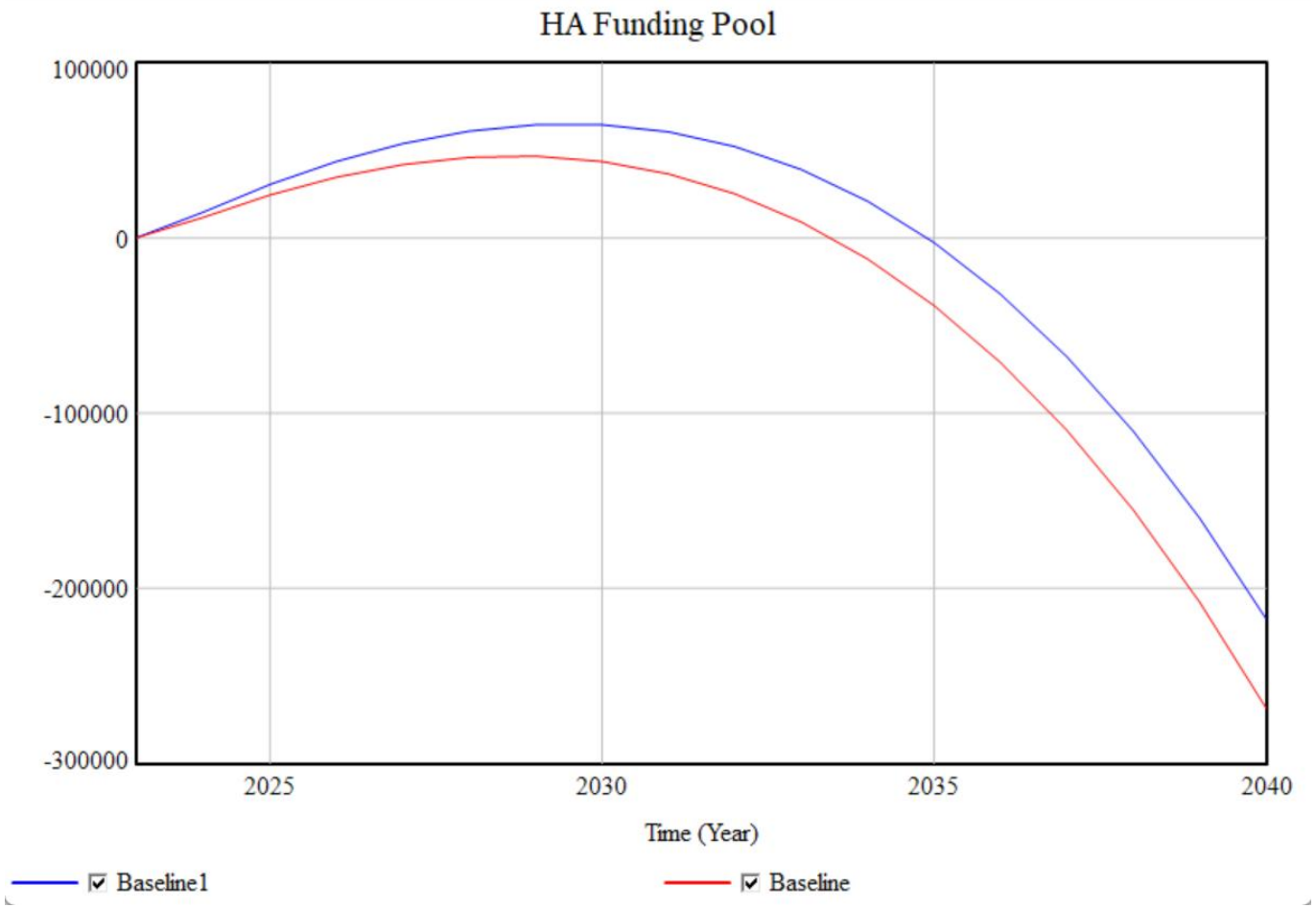
Scenario Analysis

- **Baseline**
- **Scenario 1: Increase 3 billion HKD to medical fee revenue every year;**
  - **According to the latest medical fee reform announced by Bureau of Health, the additional cost saving each year will add up to 3 billion HKD.**



Scenario Analysis

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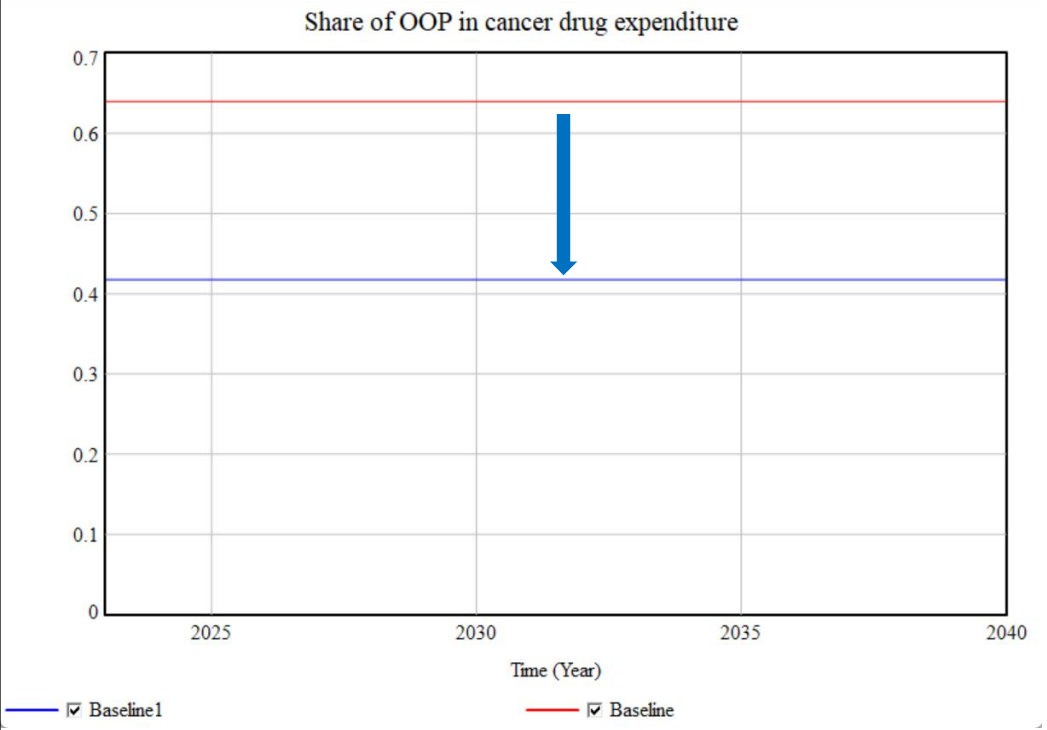


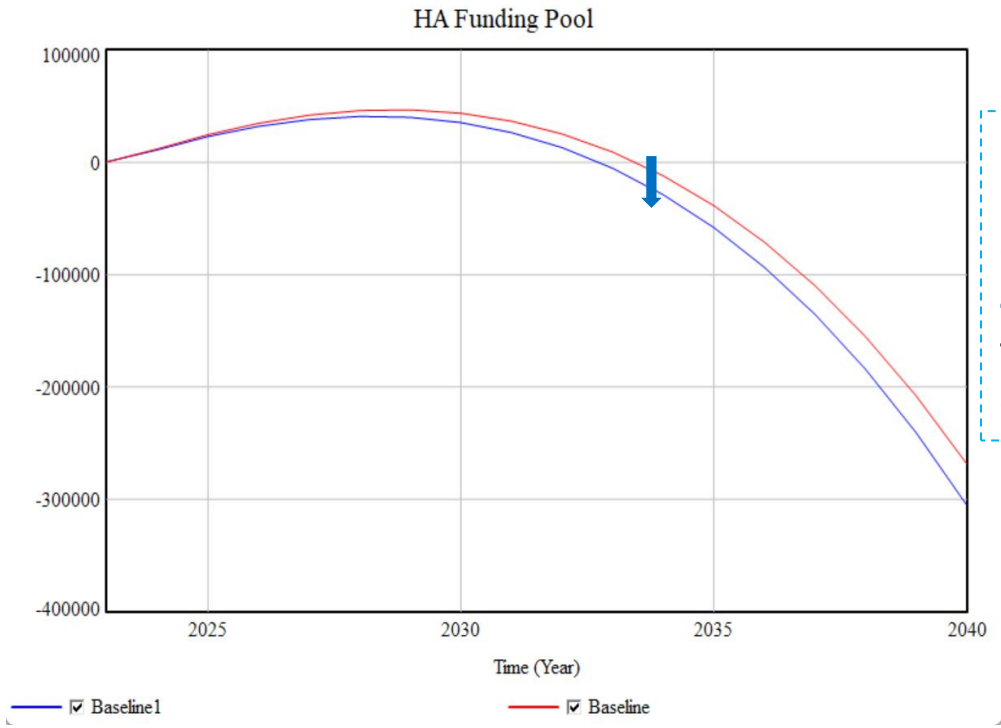
Prediction:
The depletion of HA funding pool will delay one year, while it will sill remain unsustainable in the long-term.

Scenario Analysis

- **Baseline**
- **Scenario 2: Increase the percentage of cancer patients eligible for safety net from 3.5% to 10%;**

➢ **Current safety net criteria is strict, we propose relaxing criteria by allocating more funding to safety net.**





Prediction:
Share of OOP will decrease from 64% to 42%, while the HA funding pool will also decrease.

Conclusion and limitations

1. The developed system dynamics model functions as a “laboratory for policy experiments” to assess policies aimed at improving cancer drug affordability within the HA;
2. The model incorporates several assumptions (e.g., constant GDP growth and cancer incidence rates), which may not account for unexpected economic or demographic changes, though it supports ongoing adjustments;
3. The precision of the model’s predictions depends on the validity of its parameter inputs, necessitating further refinement with real-world data.

Thank you!!

***Email*: williamhuang@link.cuhk.edu.hk**