Reforming premium amount in the Indonesian National Health Insurance System program using system dynamics

Diva Kurnianingtyas¹, Budi Santosa¹ and Nurhadi Siswanto¹*  

Abstract: The National Health Insurance System (NHIS) is a government program to help the health needs of its population such as in Indonesia (INHIS). However, there are obstacles to implementing it, which is shown by the results of program evaluations every year that there is a deficit problem, starting in 2014 until 2019 and even expected to increase in the following years. One of the possible deficits is due to inefficient patient behavior and referral system which will affect the premium amount. The goal is to evaluate and plan further policies with efficient premiums amount. System dynamics is used to simulate the effects of ability-to-pay, willingness-to-pay, salary, age, health cost each customer, and fund inventory. The historical data are used from INHIS from 2014 to 2019, then projected until 2030. The simulation results show that the health costs considered for determining the premiums are critical to the financial stability. If the premium is not in accordance with the customer’s ability, the government will have to subsidise to avoid deficit. In addition, PPU customers who are already retired will automatically become to BP customers, which will also affect INHIS ‘financial condition.

Subjects: Operations Research; Systems Engineering; Control Engineering; Healthcare Administration and Management

ABOUT THE AUTHOR

Diva Kurnianingtyas is a Doctoral Student in the Department of Industrial and Systems Engineering, Institut Teknologi Sepuluh Nopember, Surabaya, Indonesia. Afterwards, she is a fast-track scholarship awardee from undergraduate to a doctoral degree obtained from the Ministry of Research and Technology or National Research and Innovation Agency in 2017. In addition, she is a Bachelor of Computer Science, graduated from the University of Brawijaya, Malang, Indonesia. She is focusing on research in health planning and management, data mining, artificial intelligence, and simulation modelling.

PUBLIC INTEREST STATEMENT

This paper studies a comprehensive overview of Indonesian National Health Insurance System (INHIS) problems, accompanied by various supporting literature. One of the crucial factors affecting the financial stability of the INHIS is the patient referral mechanism and the amount of the premium. Development of system dynamics considers the ability to pay, willingness to pay, salary, age, health costs of each customer, and the availability of funds for INHIS problems. Afterwards, construction model planning from the combination of existing models and proposed models for further policy determination on INHIS issues. The problem of this financial deficit is happening in INHIS that still facing obstacles in building Universal Health Coverage (UHC) health insurance. In addition, detailed analysis and discussion by adding various scenarios and possible future research.
Keywords: System dynamics; simulation; National Health Insurance System (NHIS); premium amount; referral mechanism; financial strategy; BPJS health

1. Introduction

The NHIS (National Health Insurance System) is a program designed by the government so a country can achieve UHC (Universal Health Coverage). NHIS is used as a tool for basic health needs for everyone who has paid premiums, independently or collectively (Evans & Etienne, 2010).

The WHO (World Health Organization) provides information on implementing NHIS in order to achieve UHC. However, in its implementation, NHIS faces many moral hazard problem, especially the problem of financial budget deficits that increase every year (Widiastuti, 2018), as happened with the NHIS in Indonesia. The deficit began in 2014 with 1,94 trillion IDR (Health, 2014) and increased to 9,2 trillion IDR in 2018 (Health, 2018). The deficit problem occurs because the total revenue received is smaller than the total burden borne. In addition, the deficit occurred due to a decline in the value of equity from the INHIS (Indonesian National Health Insurance System) (Mas’udin, 2017). It means when equity decreases, it is most likely healthcare provided will be limited in order to maintain a financial balance (Saifuddin, 2002). One possibility of a deficit in INHIS fund is moral hazard in the form of inefficiency (Maryatmo & Ellyawati, 2019).

The moral hazard to INHIS is caused by changes in patient behavior. Patients having become customers of the INHIS tend to visit health facilities more frequently. According to Maryatmo and Ellyawati (2019), patients who pay their premiums independently are more likely to ask for service to health facilities than patients whose premiums are partly or wholly paid by other (government or employer). PBPU (Pekerja Bukan Penerima Upah/non-salary workers) customer is a type of customers who pay contributions independently. The existence of this category provides a great opportunity for moral hazard due to uncontrolled premium payments regularly (Dartanto et al., 2020).

In addition, based on BPJSK (BPJS Kesehatan/Social Security Health Agency) data in 2014, 33.5% was used for inpatient claim costs and 30% for outpatient claim costs, so 63.5% of claim costs were dominated by payment of catastrophic disease costs. Catastrophic disease is a degenerative and chronic disease such as kidney failure, blood disorders, cancer, and heart disease, namely hemophilia and thalassemia (Wati & Thabrany, 2016). It means that the INHIS customer is dominated by risk customers rather than healthy customers, resulting in higher service fees and loss of INHIS, which will affect the premium amounts (Maryatmo & Ellyawati, 2019).

Other inefficiencies caused by health services through the referral system have not worked well. FKTP (Fasilitas Kesehatan Tingkat Pertama/primary care) refers to patients excessively and disproportionately, who in fact, do not need to be referred to FKRTL (Fasilitas Kesehatan Rujukan Tingkat Lanjut/advanced care), resulting in INHIS incurring losses because it pays higher fees than what it should because the progressive payment system is implemented in FKRTL. One of the causes of inefficient referrals is the long waiting time to obtain health services which will affect the increase in health costs because the patient will ask to be referred to a better service, thus affecting the health cost borne by the INHIS (An & Chen-Ritza, 2010). Next, the INHIS will establish a policy to increase the amount of customer premiums to balance the fund inventory.

The moral hazard problem currently being encountered by INHIS is the financial deficit budget problem. The INHIS problem can be traced by identifying the crucial variables in the causal relationship to find the contributing factors. The SD (system dynamics) approach is used to guide systemic, strategic decision-making by identifying how the system behaves from relationships between variables (Bayer et al., 2010; Srijariya et al., 2008). The advantage of SD is that it can provide an overview of policy plans of complex systems. The INHIS has a complex system that can be seen from each of its variables, having links and relationships with other variables, and
producing dynamic outputs. Therefore, from this explanation, the characteristics of SD are compatible with this problem so it is suitable to be implemented in INHIS problems (Sterman, 2002).

The SD model is usually used to estimate complex systems in the long run. SD has proven useful in finding solutions to dynamic complexity (Georgiadis & Besiou, 2008). For example, Qiu et al. (2015) dynamically explore logistical requests so they know the storage and shipping paths needed to determine the appropriate logistics policy to improve logistics services. Then, Rad and Rowzan (2018) use SD to model the control and planning of portfolio project progress and maximize human resources. In the problem, SD can help to choose suitable projects so they can achieve strategic organizational and project goals.

In addition, SD has been implemented in a variety of operational and policy issues. Several researchers have found solutions to health problems using SD (Homer & Hirsch, 2006). For example, Wolstenholme (1999) implemented SD to develop policies on the use of health facilities in the UK. The policy is focused on cooperation between health sectors when serving patients, thereby reducing patient numbers requiring continuous care in health facilities. Grida and Zeid (2019) also applied SD to simulate the hospital system with a scenario that all types of patients were served. However, all hospital systems have limited resources. Then, the results obtained from the SD model are used to determine the appropriate resource capacity.

The SD approach can be used as a policy maker in the health insurance financial budget. For example, Wang et al. (2015) conducted a simulation and analysis of THE (Total Health Expense) from 2002 to 2012 related to financial sources and other indicators, such as GDP (Gross Domestic Product) and THE per capita. Another researcher, Grösser and Techn (2005) explored the factors that influence health insurance funds in Germany so they can ensure that the funds are balanced. Furthermore, Wu et al. (2018) investigated the factors that influence the CHE (Catastrophic Health Expenditure), then evaluated their effects to find proposed strategies to reduce problems in the Chinese public health insurance system.

From the above review, SD is suitable for dynamic and complex problems such as the INHIS problem. Previously, the INHIS problem was modelled, but only focused on the financial budget sector as studied in Kurnianingtyas et al. (2019b) or in combining the customer sector and financial budget, as discussed in Kurnianingtyas et al. (2019a). Unlike the case with this research, SD is used to develop and simulate collaborative models of the health facility, customer, and financial budget (part of INHIS) sectors so key variables that can cause deficit problems can be obtained. The built model is based on variables obtained from literature in conformity with the conditions of the problem. Therefore, SD plays a vital role in contributing to solving financial budget problems in order to encourage the sustainability of the INHIS program.

Based on the previous explanation, INHIS is encountering moral hazard which may be caused by inefficient premium amounts and the patient referral system due to changes in customer behavior and ineligible management. The objective is to identify the important factors associated with the stability of the fund inventory, especially inefficiency premium amount, using SD tool. The proposed model of the patient referral system has been carried out (see Kurnianingtyas et al. (2019a, in press)). Then, also to conduct an INHIS evaluation by studying the behavior between variables occurring in INHIS modelled by SD. Furthermore, the study will present a proposed model used for planning in determining the next INHIS policy.

The research is divided into several parts, namely Section 2 explains about INHIS. The next section (Section 3) shows the moral hazard that occurred and what the government has done for INHIS, then explains what will be done in this study. Next, Section 4 describes the conceptual model and mathematical formulation accompanied by an explanation of the data collection process and the established assumptions. Furthermore, Section 5 presents the model testing process and Section 6 discusses the results of the sensitivity analysis. Afterwards, Section 7 and
8 explains the conclusions and limitations of this study so it can be used as an idea for further research.

2. Indonesia National Health Insurance Systems (INHIS)

BPJSK (Badan Penyelenggara Jaminan Sosial Kesehatan/Social Security Health Agency) must have very careful planning of INHIS universal health coverage goals. The aim is to progressively expand coverage by providing a comprehensive package of benefits at minimal costs. Based on the previously detailed explanation, the history of the establishment of the INHIS will be summarized in Table 1.

2.1. Coverage

According to the WHO, there are three critical dimensions influencing the implementation of NHIS, namely the percentage of population coverage, whether or not a guaranteed health service package is complete, and the percentage of health cost coverage being paid by the population. These three dimensions are mainly based on the level of income and the level of welfare as well as health in a country (Evans & Etienne, 2010). In this regard, NHIS needs to consider the risk of each individual before determining the premium (Zweifel, 2007).

| Year | The development of NHIS in Indonesia |
|------|-------------------------------------|
| Dutch colonial era | Health insurance in Indonesia had already existed. |
| 1949 | The Minister of Health, Prof. G. A. Siwabessy, proposed Universal Health Insurance which only covers the customer of civil servants and their families. |
| 1968 | The government established regulation of the Minister of Health Number 1 of 1968 concerning the formation of a health maintenance fund management agency BPDPK. |
| 1984 | The government set Government Regulation Number 22 and 23 regarding the changing status of Health Maintenance Fund Management Agency to State owned Enterprise, namely PHB (Perum Husada Bhakti) and health care for PNS (Pegawai Negeri Sipil/civil servants), pension recipients such as civil servants, Indonesian armed forces, and other state officials including their family members. |
| 1991 | Based on Government Regulation Number 69 of 1991, the customers of the health care insurance program managed by PHB also included veterans, independence pioneers and their family members. In addition, the companies were permitted to extend their customers to other entities as voluntary customers. |
| 1992 | The name of PHB changed to PT (Perseroan Terbatas/limited company) of Askes (Asuransi Kesehatan/health insurance) according to Government Regulation Number 6 of 1992. |
| 2004 | The government established Law no. 40 of 2004 concerning the National Social Security System. |
| 2004 | Based on the Decree of the Minister of Health of the Republic of Indonesia Number 12/41 of 2004, PT Askes implemented a health insurance program for the poor known as the Askeskin (Asuransi Kesehatan Keluarga Miskin/Poor Family Health Insurance) program. |
| 2008 | Based on the Letter of the Minister of Health of the Republic of Indonesia Number 112 of 2008, PT Askes was assigned to carry out the customer management for the Jamkesmas (Jaminan Kesehatan Masyarakat/Public Health Insurance) program which includes management of customer, service, and organizational. On 6 October 2008, PT Askes established a subsidiary company that will manage the Commercial Askes customer. Based on the Notarial Deed Number 2 of 2008, a subsidiary of PT Askes was established under the name PT AJII (Asuransi Jiwa Inhealth Indonesia/Inhealth Indonesia Life Insurance). |
| 2009 | Based on the Decree of the Minister of Finance Number Kep-38/KM.10/2009, PT AJII as a subsidiary of Askes has obtained its operational license. |
| 2011 | The government issued BPJS Law Number 24 of 2011 concerning PT Askes officially appointed to be the BPJS which covers health insurance for all Indonesians. |
| 2014 | Issued Law no. 24 of 2011 concerning BPJS and appointed PT Askes as the organizer of the social security program in the health sector, until PT Askes changed to BPJSK. |
INHIS customers are divided into two categories according to the Social Security Health Agency Regulations 6 of 2018, namely PBI (Penerima Bantuan Iuran/contribution beneficiaries) and non-PBI, making it easier for INHIS to set premium amounts. Customers categorized as PBI are underprivileged individuals whose premiums are paid by local or central government (PP, 2018). Non-PBI customers are customers who, according to Presidential Decree 12 of 2013, are not classified as poor and underprivileged. Non-PBI customers are divided into three types, namely PPU (Pekerja Penerima Upah/salary workers), PBPU, and BP (Bukan Pekerja)non-employees). Customers fall to this PPU category include civil servants, police and military personnel, other private employees, and their family members. PBPU customers mostly consist of employees outside of work relations and independent employees and their families, while BP are mostly pensioners and war veterans. Each category has its own premium amount set and has been determined by the INHIS (Dartanto et al., 2020). The government is required to maintain the continuity of INHIS by adjusting the premium amount but that does not mean continuous increase will keep occurring.

2.2. Patient pathways
The INHIS program uses a tiered referral system (Wati & Thabrany, 2016). Patients must request health services to the FKTP first. FKTP is a health facility that is focused on general illness health services. In Indonesia, FKTP consists of Primary Clinic, Pratama Clinic, Puskesmas (Pusat Kesehatan Masyarakat/Community Health Centers), General Practitioner, and Hospital type D Pratama. FKTP is also a health facility that functions as a gatekeeper (Kemenkes, 2012). The gatekeeper function is performed by the doctor who determines the patient’s initial diagnosis, including quality of life and satisfaction, quality of care, and utilization of health services (Garrido et al., 2011). If the patient requires specialist health services, the patient is referred by a FKTP to the FKRTL. FKRTL is a health facility used by patients to obtain specialist or subspecialist services (Kemenkes, 2012). FKRTL has two levels of service, namely second or middle level health services (consisting of FKRTL Type D/FKRTL-D and FKRTL Type C/FKRTL-C), and third or tertiary level health services (consisting of FKRTL Type B/FKRTL-B and FKRTL Type A/FKRTL-A) (Dharmawon, 2017). Patients cannot immediately get FKRTL services at the second or third level without a tiered process with a referral system (Dohlan et al., 2017). Patient pathways who have registered on INHIS are illustrated by Figure 1.

2.3. Funding
Customers pay monthly premiums to INHIS through various mechanisms that have been provided. The payment of the premium is proportional to the income level of the customer concerned and then collected by the BPJSK, as explained in the SJSN (Sistem Jaminan Sosial Nasional/National Social Security System) Law. Then, the mechanism is considered more sustainable because customers are required to pay a premium, which, in turn, can reduce state expenditures and the premium will be cheaper because many customers join INHIS. One of the factors affecting INHIS’s sustainability is premium income obtained from employees, employers, and the government (Thabrany, 2008).

Figure 1. Pathways of Indonesia’s National Health Insurance System patients.
INHIS customer coverage has increased every year. In 2014, INHIS customers numbered 138 million people (54.9% of the population) and increased gradually until 2019 to 224 million (83.86% of the population). The comparison between the population in Indonesia and customers who have registered with INHIS is shown by Table 2. However, after being investigated in more detail (Table 3), for example, data in 2014, there are 138.5 million who participated in the INHIS but only 10 million (7.6%) came from the informal sector or independent customers. It becomes a common challenge in developing countries which have many workers in the informal sector, which is commonly known as the missing middle problem. Customers in the informal sector usually do not want to participate in insurance programs, including social health insurance (Bitran, 2014).

2.4. Relation of purchasing and purchaser-provider
After receiving premium payments from customers, BPJSK is responsible for managing the single trust fund for payment of health service fees to health facilities. BPJSK as the manager of a single trust fund has a good bargaining position to monitor the behavior of health facilities and health costs incurred by health facilities.

Presidential Decree 19 of 2016 explains the existence of a cooperation agreement between public and private health facilities and BPJSK. BPJSK coordinates with the Health Office in administering its contract because BPJSK carries out a selection process in selecting health facilities or what is called a credential link. Selection process is made based on the number and distribution of customer domicile, availability of health workers, human resource capabilities, and the needs of customers so health facilities can provide quality services for INHIS customers. In addition, Minister of Health Regulations 99 of 2015 also explains the procedures for cooperation between health facilities and BPJSK. In addition, the determination of the cooperation contract is valid for at least one year and can be extended according to the agreement. Illustration of cooperation between health facilities and BPJS is shown in Figure 2 (Mahendradhata et al., 2017).

2.5. Payment mechanisms
The payment mechanisms FKTP and FKRTL have differences. BPJSK pays FKTPs using the prospective of capitation payment for outpatient services and for midwifery and neonatal services using the reimbursement, known as non-capitation fees. Capitation costs are limits on the cost of reimbursement offered to providers for care coordination, increased doctor productivity, and lower healthcare costs (Agustina et al., 2019; Scutchfield & Keck, 2003). Capitation payments are expected to fund promotive, preventive, curative and rehabilitative services. Meanwhile, non-capitation costs are payment of claims based on the type and number of health services provided. The cost of capitation and non-capitation are generated by FKTP, following BPJS Regulation 2 of 2015.

The FKRTL service payment mechanism uses a claim payment system for each diagnosis. Claim costs are the most significant expenses and must be borne by the provider (Ogunnubi, 2018). Claim costs are generated by FKRTL. Health service claim costs are calculated based on Minister of Health Regulation 59 of 2014 concerning INHIS cost standards. Prospective claim payment is based on INA-CBGs (Indonesian Case Base Groups). The payment system aims to encourage service for focusing on patient, efficiency and quality, and to avoid bad incidents and moral hazard. Health costs are disaggregated by region and hospital service level. The government divides INHIS services into four regions based on distance and distribution costs, namely (1) Java and Bali, (2) Sumatera, (3) Kalimantan, Sulawesi, and Nusa Tenggara Barat, and (4) Maluku, Papua and Nusa Tenggara Timur. The detailed explanation regarding the INA-CBGs system has been regulated in the Regulation of the Minister of Health of the Republic of Indonesia 27 of 2014.

3. Problem description
The government built the INHIS in order to help the community in meeting their health needs. In Indonesia, the INHIS is managed by the BPJSK. The obstacle that still occurs in the NHIS in
Indonesia is that the total of fund inventory is either negative or deficit. One possibility of a deficit in INHIS fund is inefficiency.

Inefficiency occurs due to changes in patient behavior and the system designed by INHIS is still not optimal. Patients who have become INHIS customers tend to frequently ask for health services. It means awareness of health in the community is increasing. However, it is not balanced with qualified resources. There are limited resources and essential infrastructure in health facilities to provide health services (Luti et al., 2012). The limitation is indicated by the high number of referrals, so it is important to study the implementation of the referral system by comparing it with the referral system guidelines from the Regulation of the Minister of Health of the Republic of Indonesia 1 of 2012 and the Guidelines for the National Referral System. As a result, INHIS suffered

Table 3. INHIS customers, based on type of customers in 2014

| Type of customers | Total of customers | Proportion |
|-------------------|-------------------|------------|
| Contribution beneficiaries (Penerima Bantuan Iuran/ PBI) | | |
| Subsidized members from central government as Jamkesmas | 86,400,000 | 62.37% |
| Subsidized members from central government as Jamkesda | 9,437,667 | 6.80% |
| Salary workers (Pekerja Penerima Upah/PPU) including their family members | 27,234,911 | 19.66% |
| Non-salary workers (Pekerja Bukan Penerima Upah/ PBPU) including their family members | 10,561,190 | 7.62% |
| Non-employees (Bukan Pekerja/BP) including their family members | 4,890,901 | 3.60% |
| Total | 138,524,669 | 100% |

Table 2. Percentages of Indonesian population and INHIS customers

| Year | Population | Total (people) | Customer coverage |
|------|------------|----------------|-------------------|
| 2014 | 252,200,000 | 138,524,669 | 54.9% |
| 2015 | 255,461,686 | 156,790,287 | 61.38% |
| 2016 | 258,704,986 | 171,939,254 | 66.66% |
| 2017 | 261,890,872 | 187,982,949 | 71.78% |
| 2018 | 265,015,313 | 208,054,199 | 78.5% |
| 2019 | 267,289,750 | 224,149,019 | 83.86% |

Indonesia is that the total of fund inventory is either negative or deficit. One possibility of a deficit in INHIS fund is inefficiency.

Inefficiency occurs due to changes in patient behavior and the system designed by INHIS is still not optimal. Patients who have become INHIS customers tend to frequently ask for health services. It means awareness of health in the community is increasing. However, it is not balanced with qualified resources. There are limited resources and essential infrastructure in health facilities to provide health services (Luti et al., 2012). The limitation is indicated by the high number of referrals, so it is important to study the implementation of the referral system by comparing it with the referral system guidelines from the Regulation of the Minister of Health of the Republic of Indonesia 1 of 2012 and the Guidelines for the National Referral System. As a result, INHIS suffered

Figure 2. Cooperation between health facility and BPJSK (Mahendradhata et al., 2017).
Figure 3. INHIS under the study.

a loss due to paying higher fees than it should have, due to unnecessary referrals. If this behavior is carried out continuously, the fund inventory will continue to encounter a deficit and the government will evaluate the amount of customer premiums to stabilize the financial balance. In addition, based on BPJSK data in 2014, 63.5% of service claim costs were dominated by payments for catastrophic diseases such as kidney failure, blood disorders, cancer, and heart disease (Wati & Thabrany, 2016). It means INHIS customers are dominated by risky customers rather than healthy customers, so higher service costs and INHIS losses will also have an impact on the premiums amount.

Based on the moral hazard occurred, INHIS has made adjustments to the premium amount as stated in Presidential Regulation 111 of 2013, 82 of 2018, and 64 of 2020 in order to balance INHIS finances. In addition, the government intervened by providing bailout funds for INHIS in 2015, 2017 and 2018 amounting to 1,071 trillion, 3,6 trillion and 10,2 trillion, respectively. The government also enacted Minister of Health Regulation 53 of 2017 which regulates 75% of the allocation and 50% of cigarette excise to reduce the INHIS deficit.

There are many approaches INHIS and the government have taken to stabilize the finance. The INHIS made the adjustment by increasing the premium amount, but it still encountered deficit. An increase in premiums will reduce the patient’s WTP (willingness-to-pay) premiums when in a healthy condition because the Indonesian public’s awareness of their health needs is still low (Mahendradhata et al., 2017). In addition, the government’s policy on increasing excise taxes also still finds problems in the implementation of earmarking funds, both DBH CHT (Dana Bagi Hasil Cukai dan Hasil Tembakau/Excise and Tobacco Production Sharing Funds) and cigarette tax, ranging from administrative problems to monitoring issues. In fact, the use of the DBH CHT and cigarette tax is still not optimal.

Therefore, the study aims to find a solution to the moral hazard problem currently happening in Indonesia by designing a proposed model related to the premium amount and the patient referral system. Then testing the model to find a better model so it can be proposed in further policy planning. The INHIS described in this study is shown by Figure 3.

Currently, not all residents in Indonesia participate in the INHIS program. Individuals will register themselves as INHIS customers according to their ATP (ability-to-pay) which is based on the salary and WTP (willingness-to-pay) which is based on priority needs and policies on the premium
amount offered. The provisions for the premium amount set by INHIS are divided into four categories, namely PPU, PBPU, PBI, and BP. Then, the amount of the customer’s premium is based on their choice of the service class and the average income influenced by the economic growth rate and GDP (Gross Domestic Product).

INHIS customers requesting health services must use a tiered referral system. Customers are required to request health services at FKTP. If the doctor’s diagnosis suggests the patient be referred, the patient will be referred to FKRTL, which is at the middle level (FKRTL-1). Next, if the FKRTL-1’s doctor also recommends the patient be referred to FKRTL, which is at the tertiary level (FKRTL-2), then the FKRTL-1’s doctor will make a referral letter. When the patient no longer needs
specialist and subspecialty services on FKRTL-1 and FKRTL-2 but the patient still needs health control, the doctor will refer the patient back to a FKTP. Inpatient services are based on services that have been selected by customers consisting of classes 1, 2, and 3. All services on FKTP, FKRTL-1, and FKRTL-2 generate health service costs which will be billed to INHIS.

4. SD model

4.1. Data collection
The data collected are used for parameter input values in the SD model. The study uses historical data from the BPJSK and the BPS (Badan Pusat Statistik/Central Statistics Agency) from 2014 to 2019. BPJSK is a legal entity that organizes in INHIS. Historical data are obtained from the BPJSK website and the BPS website. The mechanism for calculating premium income and service costs is adjusted to Law 40 of 2004. The source of each parameter is shown in detail in Appendix 1.

4.2. Assumptions
Health costs undergo inflation every year, so there is a need for system adjustments to maintain financial stability, for example, adjusting the premiums amount. The increase in the premium amount is based on ATP, WTP, health costs, and financial conditions. ATP and WTP affect the addition of new customers annually. If its condition allows adjustments to be made, then the premium amount will be calculated based on the total health costs equal to the premium amount.

Figure 6. Stock and flow diagram on INHIS.
so as to find a gap in health costs that should be paid by customers and which are used as additional premiums. When there are other costs that cause budget deficits, BPJSK will have to stabilize its finances, for instance, by seeking government grants. In addition to the residents’ salary parameters, economic growth rate also affects other incomes obtained by INHIS. Registered customers are considered to always paying the monthly premium.

In this study, the referral system was based on a single case diagnosis provided by a doctor and INHIS only reimbursed medical expenses based on the diagnosis. Health service costs include outpatient, inpatient, and emergency costs. The differences in attributes of health facilities (Class 1, 2, and 3) and customers (PPL, PBSU, PBI, and BP) will be combined using age attributes, which are divided into three levels (Wati & Thabpany, 2016), consisting of young (0–29 years), adult (30–59 years), and old (> 59 years) to make it easier to adjust premium settings. PPU customers are assumed to be 30–59 years old, which is categorized as the adult customers. Indonesian employees who retired at the age of 60 (PP, 2008), belong to old customer category. Thus, they will be automatically eligible to become BP customers. In addition, PBI and PBPU customers come from all age categories.

All parameter values were obtained from the results of data collection by the researcher. Then, there are four types of FKRTL, namely FKRTL types A, B, C, and D, but only two types are used. The two types are FKRTL-1 and FKRTL-2 which are illustrated in Figure 1 because the referral mechanism has been discussed in detail in previous studies (see Kurnianingydas et al. (1)). However, there are several parameters that have no value, then the researcher projected data for 2019 and above with the condition that the MAPE (Mean Absolute Percentage Error) value is less than 10%. The WTP (willingness-to-pay) parameter is assumed to have the same value as the premium amount and it does not have an effect on the number of customers because the data related to these parameters are still not available. Afterwards, the patient value is assumed to be part of the customer parameter so the patient is considered to only be able to carry out a one-time healthcare process unless recommended by the doctor to do referral back.

### 4.3. Model construction

SD is a field of study of structure and behavior used to determine effective policies in complex problems. In this context, the system is conceptualized as a physical and information (stock) state variable that can be accumulated, exhausted, or increased by a variable rate (flow). All variables are related through a closed circuit that forms cause and effect (feedback loops). The model was built with the help of Stella Architect 1.9.4 licensed tools. The steps in doing elementary modelling on the INHIS are shown in Figure 4.

SD modelling uses qualitative and quantitative analysis methods, as shown in Figure 4. The first stage is the qualitative analysis. The stage is required to build a CLD (Causal Loop Diagram) that represents the INHIS problem to be solved. The compilation of CLD is based on various research methods, such as interviews and literature, to obtain related variables. Then, CLD will be transformed into SFD (Stock Flow diagram). SFD is an embodiment of a simulation model that shows the interrelationships between variables in the INHIS that are affected by time.

The quantitative analysis phase is carried out in the process of formulating mathematical equations into SFD. The simulation model that has been built must be verified and validated first. If the validation test fails, then, following the literature, the initial CLD hypothesis must be reconstructed until the SD model is successful in the validation test (Sterman, 2002). SD models that have been declared valid will be analyzed using alternative what-if scenarios in order to improve system performance.

SD has been used in several health sector policy issues. Thus, the model to be built is formed from variables obtained from several literature. For example, the number of patients served affects patients referred to advanced care, (Wu et al., 2018), the premium amount affects income,
patients served to generate healthcare costs (Li et al., 2018), expenditure and income having an influence on the fund inventory (Wolstenholme, 1999), other costs, non-capitation, and capitation having an impact on expenditure (Kurnianingtyas et al., 2019a), the number of customers influences the number of patients on a FKTP (Kurnianingtyas et al., 2019b), and the number of patients on a FKTP influences the number of patients on an FKRTL (Homer & Hirsch, 2006). The model formed is shown in Figure 5.

4.4. Conceptualization and causal loop diagram

The structure of the CLD is based on some of the literature in the previous section. The structure has two main components, namely negative feedback (balancing loop) to maintain a balanced relationship and positive feedback (reinforcing loop) to strengthen the relationship (Dulac et al., 2005). A positive relationship is a relationship structure that gives an interaction to oneself to produce an increase or decrease. A positive relationship is indicated by a “+” sign, which means that the variable will change in the same direction. For example, if the first variable decreases, then the second variable also decreases. The relationship will result in improvement, increase deviation, and strengthen change (Sterman, 2010). Conversely, a negative relationship is indicated by a “−” sign, which means the value of the variable will change in the opposite direction. The description of the CLD of the INHIS system, as shown in Figure 5, is explained below. The CLD has four reinforcing loops (loops 1, 6, 7, and 9) and balancing loops (loops 2, 3, 4, 5, and 8). As a reminder, in this study, variable writing will be written in underline.

Loop 1 shows the impact of an increase in Birth caused by an increase in Population. Population increases, Birth increases.

Loop 2, the increase in Death will affect the decrease in Population. Increased Population affects the increase in Death.

Loop 3 presents the effect of increase in Customer caused by increase in ATP, Population’s salary, and Population. Customer increases, so FKTP patients’ birth, FKTP patients died, Patients birth, Patients died, Birth rate, Birth, Population, and Death increases. Increasing Death influence will decrease Population.

Loop 4, the increase in FKRTL-1 patients is influenced by FKTP patients, Customer, ATP, Population’s salary, and Population. An increase in FKRTL-1 patients affects an increase in FKRTL-1 patients’ birth or FKRTL-2 patients died, FKTP patients’ birth, FKTP patients died, Birth rate, Birth, Population, and Death. Increasing Death has an impact on decreasing Population.

Loop 5 shows the impact of an increase in FKRTL-2 patients caused by an increase in FKRTL-1 patients, FKTP patients, Customer, ATP, Population’s salary, and Population. FKRTL-2 patients increase, FKRTL-2 patients’ birth, FKRTL-2 patients died, Patients birth, Patients died, Birth rate, Birth, Population, and Death increases. Increasing Death influence will decrease Population.

Loop 6 presents the effect of increase in FKRTL-2 patients caused by increase in FKRTL-1 patients and FKTP patients. FKRTL-2 patients increase, so FKRTL-2 patients referred back and FKTP patients increases.

Loop 7, the increase in FKRTL-1 patients will affect the increase in FKRTL-1 patients referred back. Increased FKRTL-1 patients referred back affects the increase in FKTP patients and FKRTL-1 patients.

Loop 8 presents the effect of increase in Income caused by increase in Premium income and decrease in Fund inventory. Income increases, so Fund inventory increases.
Finally, loop 9 indicates the changes that occur to Premium amount; both increase and decrease are affected by Health cost, Customer, and WTP.

### 4.5. Stock-flow diagram and mathematics

The next stage is to do mathematical formulation on the simulation model that has been built. CLD in Figure 5 is transformed into mathematical equations so it can be solved using simulation software by sectors, as seen in Appendix 2. The study presents the stock and flow structure represented by Loop 1, 2, 3, 4, 5, 6, 7, 8, and 9 in Figure 6, commonly called the SFD. SFD describes the system in a complicated way so it can provide an interpretation of the feedback mechanism mathematically. The dynamic behavior of INHIS influences the decision-making process related to financial problems that continue to experience deficits. This section focuses on explaining the structure of mathematical equations that affect the premium amount and financial budget of the INHIS.

Based on Figure 6, Customers need of healthcare are required to go to FKTP (primary care) first. FKTP patients can carry out the delivery process or can even do a check whether the patient has died or not. FKTP patients are an INHIS customer doing healthcare on a FKTP. When FKTP patients perform the process of giving birth, that will increase the number of Births in the Population flow. Meanwhile, FKTP patients who have been declared dead will increase the number of Death. It also happens to FKRTL (advanced care) level 1 (FKRTL1) and FKRTL level 2 (FKRTL2). The relationship has been demonstrated by Loops 1, 2, and 3 on Figure 5 which will be represented in the form of a mathematical formulation on Figure 6 by Equation 1, 2, 3, 4, and 5.

\[
FKTP\text{ patients} = \text{INT} (\text{Customer} (t = 0) \times \%\text{ of FKTP patients}) + \text{Total of RB patients to FKTP}
\]  

(1)
Customers birth = (FKRTL – 1 patients birth + FKTP patients birth + FKRTL – 2 patients birth) \( (2) \)

Birth = (Non – customers birth + Customers birth) \( (3) \)

Customers death = FKTP patients died + FKRTL – 1 patients died + FKRTL – 2 patients died \( (4) \)

Death = (Non – customers death + Customers death) \( (5) \)

Patients who obtain health services in a FKTP are allowed to be treated for outpatient care or must be referred to the FKRTL-1 because the illness suffered cannot be treated in a FKTP. Furthermore, FKRTL-1 patients receive healthcare recommended by doctors. If FKRTL-1 patients are said to be improving but still require periodic control, then the doctor at FKRTL-1 will make a back referral to FKRTL-1 patients. It is also done by FKRTL-2 doctors who provide back referrals to FKRTL-2 patients when the patient’s condition requires control of their health condition. The logic of the equation corresponds to Loop 5 and 6, as illustrated in Figure 5. Then, its relationship will be written in Equations 6, 7, and 8 below.

FKRTL – 1 patients referred back = FKRTL – 1 patients referred + % of FKRTL – 1 patients referred \( (6) \)

FKRTL – 2 patients referred back = FKRTL – 2 patients referred + % of FKRTL – 2 patients referred \( (7) \)

Total of RB patients to FKTP = FKRTL – 1 patients referred back + FKRTL – 1 patients referred back \( (8) \)

Customers make monthly premium payments based on the salary and healthcare class selected by the Customer. Premium payment is INHIS main income to maintain program sustainability by stabilizing Fund inventory. The stability of Fund inventory is very dependent on Income and Expense.
### Table 6. ATP and Premium amount in simulation results

| Years | PBPU Class 1 (IDR monthly) | PBPU Class 2 (IDR monthly) | PBPU Class 3 (IDR monthly) |
|-------|----------------------------|----------------------------|----------------------------|
|       | ATP | Premium amount | ATP | Premium amount | ATP | Premium amount |
|       |     | Young | Adult | Old | Young | Adult | Old | Young | Adult | Old | Young | Adult | Old |
| 2014  | 167,907 | 59,500 | 59,500 | 59,500 | 109,300 | 42,500 | 42,500 | 42,500 | 84,398 | 25,500 | 25,500 | 25,500 |
| 2015  | 210,857 | 59,500 | 188,954 | 222,394 | 68,087 | 72,515 | 131,524 | 171,504 | 53,461 | 61,130 | 64,703 | 98,116 |
| 2016  | 147,204 | 59,500 | 188,954 | 222,394 | 83,750 | 80,434 | 139,666 | 196,281 | 68,213 | 61,130 | 64,703 | 98,116 |
| 2017  | 151,470 | 59,500 | 188,954 | 222,394 | 64,725 | 80,434 | 139,666 | 196,281 | 55,707 | 61,130 | 64,703 | 98,116 |
| 2018  | 92,566 | 59,500 | 188,954 | 222,394 | 33,472 | 80,434 | 139,666 | 196,281 | 28,205 | 61,130 | 64,703 | 98,116 |
| 2019  | 96,442 | 59,500 | 188,954 | 222,394 | 32,637 | 80,434 | 139,666 | 196,281 | 28,260 | 61,130 | 64,703 | 98,116 |

Significant changes to Income and Expense largely determine Fund inventory conditions. In this study, Fund inventory owned by INHIS has an impact on Premium amount, when Fund inventory undergo negative, there is a possibility that Premium amount will increase and otherwise when Fund inventory undergo a surplus, Premium amount will be decreased according to Fund inventory, and Health cost. The relation has been described by Loop 8 (Figure 5) which will be written in Equations 9, 10, 11, 12, and 13.

**Premium amount**

\[ (t + 1)_x - \text{PBPU PPU BP} = \]

\[
\begin{cases}
IN^t_{\text{Health cost used}} + \text{Premium amount}(t = 0) \text{AND Fund inventory} \leq 0, & \text{INT}_{\text{Health cost used}}(t) - \text{Premium amount}(t)_x \\
\text{else}, & 0
\end{cases}
\]

(9)

**Premium income customer**

\[ (t + 1)_x - \text{PBPU PPU BP} = \text{Premium amount}_x \times x \]

(10)

**Premium income**

\[ = \text{Premium income from PBPU customer} + \text{Premium income from BP customer} + \frac{1}{2} \]

(11)

**Premium income from PBI customer**

\[ + \text{Premium income from PPU customer} \]

(12)

**Income**

\[ = \text{Premium income} + (\text{Other income} \times \text{Economic growth rate}) \]

(13)

### 4.6. Model testing

The stages that are passed before simulating the INHIS model are the process of verification and validation. Verification is ensuring that the model implemented on the computer runs smoothly and correctly (Sargent, 2013). Meanwhile, the validation stage is the proof stage that the model is in an application that has a satisfactory level of accuracy that is consistent with the application of the model (Sargent, 2013). Validation is used to test whether the model built can describe the actual problem. In the study, verification and validation are based on the literature Sterman (2010).

In the research, the verification process is carried out by examining the formulation and unit variables of the model. If there is no error, then the model can be said to be verified. Subsequently, the proposed model must go through a validation process using t-test Sterman (2002) with the following hypotheses.
Figure 9. Scenario 1: Result of ATP, customer, and WTP impacts.

Figure 10. The feedback loop is changed in 2nd scenario.

Figure 11. Scenario 2: result of ATP, premium amount, health cost, and WTP impacts.
H_0: μ_1 = μ_2; no different

H_1: μ_1 > μ_2; Fund inventory in the proposed model is higher than Fund inventory in the existing model

α : 5% or 0.05

Decision: declined H_0 if α < 0.05 and accepted H_0 otherwise

If the simulation results obtained in the study’s proposed model are better than the existing model, then its proposed model is declared valid. The process of building an existing model until the validation process has been carried out in previous studies (see Kurnianingtyas et al. (2019b, 2020)).

Validation using t-test is based on literature Sterman (2002). The t-test was used to compare the means of the two groups. Usually in a simulation approach, the t-test is used for validation by comparing simulated and real data. The t-test has been widely used by researchers in various cases of problems, especially in the health sector (Kleijnen, 1995). For example, evaluating the effectiveness of critical care in state universities majoring in nursing (D’Souza et al., 2017). D’Souza et al. (2017) used the t-test as a tool to test pre-scenarios and post-scenarios then a tool to analyze the findings obtained from their research. In addition, Kresojević and Gajić (2019) used the t-test to analyze the application of health costs in health insurance in order to find a better solution for health insurance in the Republic of Srpska. Some researchers have applied the t-test for health problems, especially to validate the simulation; in this study, the validation uses the t-test method. The results of validation in the INHIS proposed model are presented in Table 4, and obtained value of t_{stat} about 2.904431977 and t_{critical} value (0.05;5) of 2.015048373. After that, the hypothesis testing process is carried out; if value of t_{stat} < t_{critical} then H_0 is accepted, otherwise if value of t_{stat} > t_{critical} then H_0 is declined. In this regard, the t value in the proposed model is greater than the t_{critical} value, so the t value calculation results are in the rejection area of H_0. Based on the hypothesis test, the Fund inventory of the proposed model is greater than the Fund inventory in the existing model. It can be said that the Fund inventory in the proposed model is better than the Fund inventory in the existing model because the results obtained in the proposed model are higher than the existing model. Therefore, the model built can be declared valid, as shown in Figure 7 (Yorucu, 2003).

Based on Figure 7, in existing condition, the financial budget for the INHIS continues to decline from the beginning of the program’s construction, namely 2014 to 2019. When viewed from INHIS’s fund inventory, the expenses to be paid by the INHIS are higher than income obtained. Health service costs for each customer tending to be higher than the premium amounts paid by the customer are the leading causes of the deficit. The statement follows calculating the difference of income and expense in existing condition in Table 5. Unlike the case with the simulation results of the proposed model, changes in determining the premium amounts actually affect the stability of the fund inventory, which is shown by Figure 8. The income earned by INHIS has increased by which it can balance health costs. However, even though it has increased and fund inventory is in surplus, INHIS should always conduct an evaluation every year. In addition, to determine the premium amount, it is necessary to consider other parameters such as ATP and WTP because customers are probably registered in the INHIS program but not making premium payments periodically because of the premium amount being set too high. But it could be that the customer has a high WTP when the customer wants better healthcare (McGuire et al., 2014). ATP and WTP are an important part of developing INHIS policies (Ramadhan et al., 2015). Therefore, the ATP and WTP parameter will be tested for its sensitivity, as to whether these parameters really have an effect on the system and better and more realistic solutions can be found so as to maintain the continuity of the INHIS program.
5. Willingness-to-pay sensitivity analysis and discussion

Sensitivity analysis is carried out on critical variables that are influential in order to obtain some interesting findings related to the importance of the sustainability of INHIS management designed by the government. The importance of the definition of sustainability in the INHIS relates to increased demand and limited resources, so a balanced approach is needed. In this context, sustainability is described by fund inventory, balance or even a surplus, but still in a reasonable condition. If the premium amount is too high it does not guarantee active customers to make monthly premium payments because it depends on the customer’s ATP, so it is likely that registered residents will become passive customers who only make payments when the customer needs healthcare (Ramadhan et al., 2015). It is important to note by the INHIS because it has a PBPU customer category having independence in choosing health service classes, both classes level 1, 2, and 3, according to the predetermined premium amounts. Then, residents who have not registered to become INHIS customers, when the premium amount is not in accordance with the WTP and ATP, they will not register as customers, in fact there is a possibility the customer will still register but not become an active customer. INHIS’s goal is that the health sector can reach UHC, but it is still difficult to achieve because all residents in Indonesia are still not registered as INHIS customers (Evans & Etienne, 2010). If indeed residents experience compulsion in registering INHIS because the premium amount is not in accordance with ATP and WTP and health needs are still not a priority, then it will have an impact on fund inventory. An increase of health cases affects the increase in health costs, but not accompanied by premium payments by the customer, so INHIS’s fund inventory is in deficit. Therefore, the maintenance of the INHIS depends on the long-term projection of the INHIS funding stock. Meanwhile, to develop a proposed model by modifying the patient referral system, as Kurnianingtyas et al. (2019a) already examined whether changes to the referral system have an impact on program continuity or no, these parameters are, therefore, not tested in this study.

Sensitivity analysis is needed to find the dynamic behavior of the long-term model that will be built to be used to determine the effects produced. Based on simulation results (Table 6), when ATP value tends to be lower than the premium amount, the premium amount in the old category (> 59 years) is the highest premium. Therefore, in this study, researchers conducted a sensitivity test of ATP, customer, premium amount and WTP in order to find better and more realistic solutions to problems. The sensitivity test will be divided into three scenario approaches, among others (1) when WTP is affected by premium amount then WTP and ATP affect the number of customers who pay a monthly premium, (2) when WTP is influenced by ATP and WTP affects the increase and decrease of premium amount, and (3) when WTP is affected by ATP and premium amount, then WTP affects the increase and decrease of premium amount and customer. It needs to be reiterated that the sensitivity test is only carried out on PBPU customers because they are independent customers, which is different from other customers whose premium payments are from the percentage of their salary or are paid by the government (regional or central). In addition, PBPU customers are more likely to have moral hazard than other types of customers (Dartanto et al., 2020).

5.1. Scenario 1: ATP, customer, and WTP impacts

ATP, customer, and WTP have an influence on the sustainability of the INHIS program. The relationship between these three parameters has been described by Figure 5. In the previous simulation, WTP was assumed to be the same as the premium amount and its assumption was still applied to the sensitivity test. Then, the difference between the previous simulation and the sensitivity test is WTP has an effect on the number of customers when the parameter value of ATP is less than WTP, then the customers will decrease by 20%, 40%, 60%, and 80%.

Based on the results of the sensitivity test presented by Figure 9, the decrease in the number of customers occurred in 2015 and above because the premium amount increased and the value of ATP was not sufficient to increase the premium amount. When the value of ATP is less than WTP, the number of customers will decrease by 20%, so the average fund inventory has decreased by
1% from 1367.7 trillion IDR to 1348.6 trillion IDR. Furthermore, if customer requirements are increased to 40%, 60%, and 80%, the average fund inventory will decrease significantly by 12%, 23%, and 34% from 1367.7 trillion IDR to 1201.8 trillion IDR, 1055.1 trillion IDR, and 908.3 trillion IDR, sequentially. From the information, it can be concluded that the change in the parameter value of the number of customers is influenced by ATP and WTP and affects the parameter value of the fund inventory. ATP and WTP customers play an important role in the INHIS program when the premium amount is not in accordance with the customer’s ability, so it is difficult for the government to urge people to join the INHIS. Even though the customers have registered, if the premium amount set is too high of their ability, the customer chooses not to pay the bill and will instead pay when the customer is in need of healthcare (Arora et al., 2015). As a result, the number of customers has decreased and the fund inventory has also decreased, so there is a need to evaluate and plan for the sustainability of the INHIS program.

5.2. Scenario 2: ATP, premium amount, health cost, and WTP impacts
In the second test, the researcher tests the ATP, premium amount, and WTP parameters described in Figure 10 shown by the gray line. The sensitivity test assumes the WTP is influenced by ATP and the parameter value of WTP affects the increase in the premium amount. Therefore, Equation 9 undergoes the modification shown by Equation 14 as follows.
Premium amount_{PBPU} = 

\[
\begin{align*}
\text{WTP} > \text{INT} \left( \text{Health cost used} \right) & \Rightarrow \text{Premium amount}(t = 0), \quad \text{AND Fund inventory} \leq 0 \quad \text{INT} \left( \text{Health cost used} \right) - \text{Premium amount}(t), \\
\text{else} & \quad 0
\end{align*}
\]

(14)

In addition, there are two conditions for observing the WTP parameters, namely the parameter value of WTP is the same as the value of ATP and the value of WTP is assumed to be 50% of the ATP value.

Based on the results of the scenario 2 sensitivity test shown in Figure 11, changes in the premium amount affected by WTP and ATP have a significant effect on fund inventory. When WTP was equal to ATP, then the average of fund inventory decreased by 42.7% from 1367.7 trillion IDR to 783.2 trillion IDR. The findings obtained are that the health services cost each customer is greater than the set premium amount, by which the ATP and WTP of the customer can be said to be less than the same as the premium amount. Therefore, when the increase in the premium
amount is based on ATP and WTP, the result is that there is no significant increase in the premium amount, only in PBPU Class 1 where changes are found. Then, when WTP equals to 50% of ATP, then the result is a decrease in the average of fund inventory of 43% from 1367.7 trillion IDR to 780.2 trillion IDR. The percentage reduction when WTP equals to ATP and WTP equals to 50% of the ATP obtain almost the same results. This is because when WTP equals to 50% of ATP, the premium amount does not change at all while at WTP equal to ATP the increase in premium occurs only in the PBPU Class 1 category; it does not have a significant impact on the average fund inventory, because the biggest customer health costs are located in the PBPU Class 3 category.

5.3. Scenario 3: ATP, customer, premium amount, health cost, and WTP impacts

The ATP, customer, premium amount, and WTP parameters are described as having a relationship shown by Figure 12. Change in the parameter value of ATP affects the WTP parameter and then its changes will affect the parameter of customer and the premium amount. Increases and decreases in the premium amount have an effect on the number of customers. The relation is a combination of scenario 1 and 2, which is represented in scenario 3. In this test, the researcher established four observation conditions, namely (1) WTP equal to ATP, (2) WTP equal to 80% of ATP, (3) WTP equal to 60% of ATP, and (4) WTP equal to 40% of ATP. In addition, when WTP is less than health cost and fund inventory less than 0, the change in premium amount will follow the WTP parameter value. Otherwise, when WTP is greater than health cost and fund inventory less than 0, then the premium amount depends on the value of health cost. Observation conditions are determined based on the behavior and patterns of Indonesian people who are still less enthusiastic about health needs so the WTP value is equal to or below the value of the ATP parameter. Afterwards, when premium amounts undergo a significant increase without considering ATP and WTP, the biggest possibility is the customers do not register with INHIS or do not actively pay periodically because they prefer to fulfill their life needs first, such as clothing, food and shelter, because health needs still not a priority and culture in Indonesia (Mahendradhata et al., 2017).

The results of the scenario 3 sensitivity test shown in Figure 13 are that the parameters of ATP, customer, premium amount, and WTP are proven to have a relationship as evidenced by a significant change in the average fund inventory. The first condition, namely WTP equal to ATP, has a significant effect of 41% on the average fund inventory (1367.7 trillion IDR to 801.8 trillion IDR). Then, for the second and third conditions they reduce the average fund inventory by 43%. The biggest change occurred in the fourth condition when the WTP was equal to 40% of ATP, namely 44% from 1367.7 trillion IDR to 771.7 trillion IDR. From the simulation results, it can be concluded that the ATP, WTP, and premium amount parameters have a relationship which affects the process of increasing and decreasing customers. Meanwhile, the parameters of WTP and health cost will affect changes in the premium amount. Thus, it can be concluded that changes in the value of the parameter number of customers and the premium amount affect the value of revenue, costs, and fund inventory. In addition, the total expenditure on health costs since the inception of the INHIS program has a higher proportion than total income. Supposedly, the contribution of customers in the monthly premium payment sees the estimated health costs generated by each customer, so the deviation of the difference between expenditure and income is not too far apart.

6. Results and discussions

INHIS sustainability is influenced by the ATP, number of customers, premium amount, and WTP, so it can maintain the stability of the fund inventory and reach UHC. The statement has been proven by the results of the sensitivity test in the third scenario which obtained significant results on the average of fund inventory. ATP parameters affect the amount of WTP and the total of customers, thus affecting the number of customers who will pay the premium and perform healthcare. Thus, the ATP and WTP are important parameters in resolving stability problems in fund inventory. Therefore, the proposed model will be used by researchers in long-term planning.
Table 7. Premium amount PPU customers and BP customers

| Premium amount | Existing condition | Sensitivity scenario test (IDR monthly) |
|----------------|--------------------|---------------------------------------|
|                | LB                 | UB                                    | 10%   | 30%   | 50%   |
| BP Class 1     | Lower (LB)         | 88.122                                | 88.122| 88.122| 88.122|
|                | Upper (UB)         | 138.233                               | 137.270| 172.868| 167.125|
|                | Average            | 122.377                               | 121.754| 142.552| 139.007|
| BP Class 2     | Lower (LB)         | 63.591                                | 63.591| 63.591| 63.591|
|                | Upper (UB)         | 110.929                               | 109.966| 145.564| 139.821|
|                | Average            | 95.542                                | 94.919| 115.718| 112.173|
| PPU Class 1    | Lower (LB)         | 55.391                                | 55.391| 55.391| 55.391|
|                | Upper (UB)         | 180.267                               | 179.304| 214.902| 209.159|
|                | Average            | 145.727                               | 145.104| 165.902| 162.357|
| PPU Class 2    | Lower (LB)         | 45.422                                | 45.422| 45.422| 45.422|
|                | Upper (UB)         | 125.085                               | 124.122| 159.720| 153.977|
|                | Average            | 102.427                               | 101.804| 122.602| 119.057|

Planning at INHIS is very necessary in order to prevent or reduce moral hazard so as to maintain its sustainability. The purpose of the planning model is to determine the dynamic behavior and effects resulting from the model built in the long term. In this study, planning is carried out by combining the existing model and the proposed simulation model that has been previously designed. The existing model was simulated from 2014 to 2019 and the proposed model was simulated from 2020 to 2030. The proposed model used is that modified for the sensitivity test scenario 3. The planning model will be executed four times with the provisions of (1) WTP equal to ATP, (2) WTP equal to 80% of ATP, (3) WTP equal to 60% of ATP, and (4) WTP equal to 40% of ATP. Meanwhile, the WTP requirement equal to premium amount in accordance with the initial proposal before the sensitivity test is not included in the planning simulation. When the WTP is the same as the premium amount but the ATP is less than the WTP, the biggest possibility is that the customer does not make regular premium payments and it could be that the customer only registers, but is not responsible for paying, so its scenario is deemed by the researchers to be not applicable to INHIS.

Some of the provisions applied to the planning simulation do not make a significant difference (see Figure 14). The findings are the difference in the amount of WTP and ATP gave a surplus result because changes in WTP from PBPU customers affected the condition of the financial budget so that the premium amounts for other customer categories would change to maintain financial stability. When viewed from the graph in Figure 14, from 2014 to 2019, the average of fund inventory tends to decrease, according to actual conditions. After 2019, the average fund inventory will slowly incline as surplus. This happened due to the future implementation of a proposed model used to determine the premium amounts in 2020, so that INHIS will reach a surplus turnover. In 2028, the main reason is based on the results of data projections that the number of customers is the same as the number of the population by which it can be said the membership coverage reaches 100% in 2027, but the average fund reserve will still undergo a surplus. Consequently, a premium raise will occur. Based on the simulation results shown in Figure 14, in 2028, when the WTP value is the same as the ATP value, the average of monthly health costs per customer is calculated as 103.904 IDR, while the average the monthly premium per customer has increased from 72.237 IDR to 112.390 IDR. The monthly health cost per customer is not proportional to the monthly premium per customer so that the fund reserve will slowly undergo a deficit again if there is no restatement of the premium amount after 2027.

The results obtained as shown in Figure 14 have yet to consider changes in the number of customers when employees who are registered as PPU customers eventually retire. Employees
who retire automatically eligible as BP customers. The premium amount paid is the same as when being an active employee, which is taken as much as 5% of the retired salary earned (PP, 2018). The scenario for changing customers of PPU to BP will be implemented from 2020 to 2030 with increases of 10%, 30%, and 50% which are simulated sequentially.

Consecutive increases in the number of BP customers result in a different financial surplus condition. Based on Figure 15, after 2019, when the first scenario is the number of BP customers increases by 10% due to financial budget of 19.9 trillion IDR is obtained, lower than the actual requirement, which is 34.1 trillion IDR. This happens because the premium comes from the actual condition is higher than the first scenario. Conversely in the second scenario, when there is an increase of 30% for BP customers, there will be a deficit of 10.4 trillion IDR in 2020 due the premium earned is lower than the premium income in the first scenario. The premium amounts obtained in the second scenario have not been able to solve the deficit problem from 2014 to 2019, so the premium amounts are re-determined in 2020. As a result, the premium amounts obtained are higher than the previous year and the surplus in the second scenario is more than the surplus in the first scenario, for example, the average premiums for BP customers class 1 increased by 10% and 30% are 121.754 IDR and 142.552 IDR, respectively. Furthermore, the number of BP customers has increased by 50% (third scenario), experiencing the same phenomenon as the second scenario. However, in the second scenario, an increase in the number of BP customers does not earn high premium income. On the other hand, the premium income of BP customers could match the premium income of PPU customers in the third scenario. The difference in the premium amounts between PPU and BP customers causes a gap in the premium income earned. This statement is illustrated in the second scenario where the premium is higher than other scenarios shown in Table 7. From the scenario, the researcher concludes that the change in the number of PPU customers to BP customers due to retirement has a very large effect on the stability of INHIS ‘fund reserve. The premium amount determined for PPU customers is higher than the premium amount of BP customers which results in a large difference in obtaining premium income.

Another solution given when INHIS ‘s fund inventory is undergoing instability is the existence of a grant from the government. Researchers assume the government will help support a complete underfunding by 2021. The amount of the grant is in accordance with the total deficit in 2019, then the government will provide grants in 2020. The government grants are about 50.9 trillion IDR implemented in four scenarios. According Table 8, government grants have a significant effect. The simulation results show that the average premiums in PBPU class 1, 2, and 3 are 100.775 IDR, 73.893 IDR and 53.599 IDR, respectively.

| Table 8. Premium amount from planning simulation with additional government grants in 2020 |
|---------------------------------------------|-------------------------------------|----------------------------------|-------------------------------------|-------------------------------------|
| Premium amount | Existing condition (IDR monthly) | Sensitivity scenario test (IDR monthly) |
|                 | | WTP = ATP | WTP = 80% *ATP | WTP = 60% *ATP | WTP = 40% *ATP |
| PBPU Class 1    | Bounds | Lower (LB) | 59.500 | 59.500 | 59.500 | 59.500 |
|                 |       | Upper (UB) | 120.153 | 101.468 | 101.468 | 101.468 |
|                 | Average |          | 102.364 | 90.775 | 90.775 | 90.775 |
| PBPU Class 2    | Bounds | Lower (LB) | 42.500 | 42.500 | 42.500 | 42.500 |
|                 |       | Upper (UB) | 91.153 | 82.468 | 82.468 | 82.468 |
|                 | Average |          | 75.481 | 63.893 | 63.893 | 63.893 |
| PBPU Class 3    | Bounds | Lower (LB) | 25.500 | 25.500 | 25.500 | 25.500 |
|                 |       | Upper (UB) | 70.153 | 61.468 | 61.468 | 61.468 |
|                 | Average |          | 55.187 | 43.599 | 43.599 | 43.599 |
Figure 16. Other planning simulation: all customers are considered capable of paying any premium despite inflation cost.

Government grants can help maintain financial conditions even though 60% of PBPU customers are not actively paying the monthly premium. This is evidenced by the number of premiums that do not change even though the WTP parameter value is reduced by 60%. (see Table 8). In addition to helping INHIS 'financial condition, government grants can reduce customer premiums, for example, customers of PBPU class 1 who are supposed to pay a maximum of 120.153 IDR monthly premium will only need to pay 101.468 IDR. The scenario can become an instant solution for solving the deficit problem as well as reducing customers’ premium payments.

Another planning scenario is to assume that the customer is able to pay whatever premium the government has set based on the customer’s salary and healthcare costs, including the inflation cost for per customer. When the fund inventory is negative, the premium amount will follow the amount of healthcare costs for per customer. Meanwhile, when the fund inventory is not in deficit, the researcher assumes that the premium amount is reduced by 5% from the previous premium amount. The expected results are dynamic and fluctuating, but stability is maintained.

As a result, INHIS’s fund inventory tends to undergo a fluctuating surplus after 2020. For example, in 2021 to 2026, the fund inventory tends to increase because the premium amount in 2021 is based on the amount of healthcare costs for per customer. Afterwards, until 2026, the premium amount will be reduced by 5% when the fund inventory does not undergo a deficit. The income is bigger for its expenses because the INHIS’s income is from other income and premium income, while expenses are obtained from other expenses and health costs, so the fund inventory is not negative in 2021 to 2026 even though the premium amount is reduced by 5%. Furthermore,
in 2029, the fund inventory was detected as negative so the premium amount needed to be adjusted again and there would be no deficit in the next year.

Based on both improvement scenarios, shown by Table 8 and Figure 16, which are implemented in the planning simulation, it can be concluded that the premium amount and health costs for per customer must be balanced or surplus because it will prevent a negative fund inventory. Regardless of health costs consider the other cost or not, the premium amount determined must balance the amount of these costs. When the premium amount is not in accordance with the ATP, the government should provide a grant, so customers can get proper health care and maintain the sustainability of the INHIS program. In addition, the policies set every year must be evaluated to determine the obstacles faced yearly so the INHIS can be immediately addressed. The government needs to monitor how much the surplus funds should be, because it is feared that there may be new moral hazard, such as corruption from internal agency.

Determining the premium amount based on age can help maintain the stability of fund inventory. Based on Table 9 which shows the range of premiums for each category obtained from the simulation results on Figure 14, adult and old categories always get the highest premium, because at this age health tends to decline so it requires more health care when young. The premium amount is also influenced by the health costs incurred at each age; therefore, it is true that the adult and old categories will cost more. PBU customer premiums get the opposite result to BP customer premiums. In Table 7, the premium amounts for BP customers are lower than the premium amounts for PPU customers whose members consist of young and adult persons. Based on these results, it is necessary to have a further study focused on determining the number of contributions for PPU and BP customers.

Age is one of the parameters that need to be considered in determining the premium amount, which is a better and realistic solution in maintaining the sustainability of the INHIS because the health needs of each age are different. In addition, the government is also making efforts to reduce health costs at young and old age by encouraging its residents to cultivate a healthy life. Based on WHO data, 60% of health factors and quality of life are related to individual lifestyle patterns (Currie et al., 2004). Many people have bad lifestyles that are affected by disease, disability, and even death. Health problems such as cardiovascular, obesity, hypertension, and joint problems can be caused by unhealthy lifestyles (Agustina et al., 2019; Farhud, 2015). In addition, the government also needs to reduce smoking habits by increasing the cost of smoking through taxation, increasing sustainable social marketing campaigns, ensuring that medical staff routinely advise smokers to quit and providing pharmacological and behavioral support to smokers (West, 2017). The problem needs to be considered because smoking causes death and disability on a large scale (Gowing et al., 2015; Services, U. D. o. H. H. a, 2004).

7. Limitations and future research
The SD model built represents the real condition of the INHIS system. The system provides overview of the sustainability of the financial budget sector owned by the INHIS from the primary income derived from the customer premiums and the most significant expenditure on health service costs. Then, the health facility sector also influences the condition of the INHIS because effective and efficient mechanisms are needed to minimize the expenditure of health services. In addition, ATP and WTP are key parameters that have an influence on customers to remain active INHIS customers, meaning they actively pay monthly premium coverage and also for unregistered populations so they have the desire to register INHIS. The SD model is built to only represent the INHIS system in normal conditions which do not consider unpredictable disasters such as pandemics.

The study has limitations that cannot be represented in the model that has been built (see Figure 3) namely only the financial budget sector is a measure of success in solving problems. The model is built only to find out the critical variables that have a significant influence on the INHIS funding stock. Therefore, there must be an expansion of the model so the problem of financial deficits can be seen from another perspective. In this study, the parameters which affect premium changes are based on customer salary, fund inventory, health cost, ATP, and
WTP, and it is still necessary to expand the number of influencing parameters such as the number of customers who have catastrophic diseases. In addition, in further research, it is also necessary to add service level parameters that will have an impact on WTP because, when the health service is good, the customers have a desire to prioritize and may pay higher premiums to maintain their health. Then, there is moral hazard that will occur when maintaining the sustainability of its program. The simulations built still did not reflect the difference between active and passive customers, so the premium adjustment still had no visible impact on INHIS customers because the actual data related to this are not available. There is still no visible effect when the premium is increased or decreased for customers who have not or are already registered. There is a possibility that registered customers do not pay premiums regularly, are called delinquent customers, even though the government has set penalty for them, but the regulations still tend to be loose so they have not provided a deterrent effect.

8. Conclusion
In this study, an SD model has been developed to represent the INHIS in the long term with stock and flow. The SD model is used to assess system performance that can find alternative solutions. The solution can be a contribution to financial sustainability in the INHIS.

There are two contributions obtained from this study. First, the development of the SD model applied to the NHIS financial problems can add to the SD literature that can solve such problems. There is little literature dealing with sub-sectors in the INHIS. Thus, new knowledge and concepts from the INHIS will be introduced into the SD simulation literature. Second, from the process of developing a conceptual model, SD can be used to create new policy strategies so they can find solutions to the INHIS financial problems that are sustainable and effective.

The study explains the contribution of INHIS-related science regarding the perspective of problems in other sectors so it can find critical factors, especially inefficiency of premium amount, which are the main problems in the INHIS. These critical factors can be used to find new policy strategies so they can support the continued success of the INHIS. In addition, the study examines the validity of the model structure in making policy strategies using an analysis of t-test. The validity is done to create better sustainable INHIS performance. The results obtained in the test provide theoretical insights in order to make policies to solve budgeting problems to create long-term INHIS performance. The SD approach proposed provides a new understanding of how to better implement the INHIS so as not to run a deficit in the fund inventory. In addition, it finds the range of premiums that should be applied to the INHIS considering ATP, WTP, health costs, and fund inventory.

There are four planning simulation scenarios, namely considering parameters (1) inflation cost, ATP, and WTP; (2) government grants, inflation cost, ATP, and WTP; (3) ATP and WTP; (4) inflation cost. Scenarios 1 and 2 obtain results that tend to be the same, namely the fund inventory continues to undergo a deficit until 2030. Meanwhile, in scenarios 3 and 4, the simulation results show the fund inventory tends to increase slowly from the previously negative fund inventory to a surplus. In addition, retired PPU customers will automatically become BP customers. This change will affect the stability of INHIS fund inventory, since the differing premium amounts between PPU and BP will cause a revenue gap. The findings obtained are that the health costs considered for determining the premium are proven to be sturdy in maintaining financial stability. If the premium amount does not match the ATP, the government must provide a grant, in order to maintain the sustainability of the INHIS program. In addition, the government needs to evaluate the INHIS program every year to find out what obstacles it faces yearly so it can be handled quickly.

In addition to knowledge contributions, the study also makes practical contributions that are relevant to the problems faced by the INHIS. The SD approach has provided an overview of causal relationships that can create strategic solutions for the INHIS. The approach enables a long-term analysis and evaluation tool. The approach model is also useful for researchers or decision-makers in developing the INHIS in a sustainable manner.
Funding
This work was supported by Kementerian Riset Teknologi Dan Pendidikan Tinggi Republik Indonesia (Ministry of Research, Technology and Higher Education of the Republic of Indonesia) [Number of grant: 3/AMD/E1/KP. PTNBH/2020].

Author details
Diva Kurnianingtyas1, Budi Santosa1
ORCID ID: http://orcid.org/0000-0003-1753-9603
Nurhadi Siswanto1
E-mail: siswanto@ie.its.ac.id/nurhadi.siswanto@gmail.com
ORCID ID: http://orcid.org/0000-0003-1148-9166
1 Department of Industrial and Systems Engineering, Faculty of Industrial Technology and Systems Engineering, Institut Teknologi Sepuluh Nopember, Kampus ITS Sukolilo, Surabaya 60111, Indonesia.

Declaration of interest statement
The authors declare that they have no conflict of interest.

Data availability statement
All data generated or analyzed during this study are included in this published article. Data input for the research process is attached in Appendix 1. The data is permitted to be published by NHS in Indonesia. Then, all formulas used in the model included in this published article are shown in Appendix 2.

Citation information
Cite this article as: Reforming premium amount in the Indonesian National Health Insurance System program using system dynamics, Diva Kurnianingtyas, Budi Santosa & Nurhadi Siswanto, Cogent Engineering (2021), 8: 1936368.

References
Agustina, R., Dartanto, T., Sitompul, R., Susiloretni, K. A., Achadi, E. L., Shankar, A. H., Shankar, A. H., Shankar, A. H., Shankar, A. H., Shankar, A. H., Shankar, A. H., Thabranj, H., Agustina, R., Dartanto, T., Sitompul, R., Susiloretni, K. A., Shankar, A. H., Shankar, A. H., Shankar, A. H., Khusun, H. (2019). Universal health coverage in Indonesia: Concept, progress, and challenges. The Lancet, 393(10166), 75–102. https://doi.org/10.1016/S0140-6736(18)31647-7
An, L., & Chen-Ritzo, C.-H. (2010). Integrated Healthcare Delivery and Health Insurance Models for Studying Emergency Department Utilization. Proceedings of the 28th International Conference of the System Dynamics Society. Seoul, Korea.
Arora, V., Moriates, C., & Shah, N. (2015). The challenge of understanding health care costs and charges. AMA Journal of Ethics, 171, 1046–1052. https://doi.org/10.1001/journalofethics.2015.17.11.stas1-1511
Bayer, S., Bolt, T., Kapsali, M., & Brailsford, S. (2010). The social role of simulation models. Proceedings of the 28th International Conference of the System Dynamics Society. Seoul, Korea.
Bitran, R. (2014). Universal Health Coverage and The Challenge of Informal Employment: Lessons from Developing Countries. Health, Nutrition, and Population (HNP) discussion paper. World Bank. Washington, DC. https://openknowledge.worldbank.org/handle/10986/18637
Currie, C., Roberts, C., Setertobuile, W., Morgan, A., Smith, R., Samadi, O., Barnekow Rasmussen, V., & Organization, W. H. (2004). Young people's health in context: Health Behaviour in School-aged Children (HBSC) study: International report from the 2001–2002 survey. WHO Regional Office for Europe. https://apps.who.int/iris/bitstream/handle/10665/107560/e82923.pdf
D’Souza, R., Venkatesaperumal, R., Chavez, F., Parahoo, K., & Jacob, D. (2017). Effectiveness of simulation among undergraduate students in the critical care nursing. International Archives of Nursing Health Care, 3(4), 1–8. https://doi.org/10.23937/2469-5823/1510084
Dahlman, M., Setyopranoto, I., & Trisnantoro, L. (2017). Evaluation of the Implementation of the National Health Insurance Program for Stroke Patients at RSUJ Dr. Sardjito. Indonesian Journal of Health Policy (JJKI), 6(2), 73–82. https://doi.org/10.22146/jkki.v6i2.28934
Dartanto, T., Halimatussadiah, A., Rezki, J. F., Nurhasana, R., Siregar, C. H., Bintaro, H., Sholihat, N. K., Sholihat, N. K., Yuan, E. Z. W., Soeharno, R., & Soeharno, R. (2020). Why Do Informal Sector Workers Not Pay the Premium Regularly? Evidence from the National Health Insurance System in Indonesia. Applied Health Economics Health Policy, 18(1), 81–96. https://doi.org/10.1007/s40258-019-00518-y
Dharmawan, I. R. (2017). Reflections on the implementation of the National Health Insurance in dentistry services at the first level of health facilities in Tangerang City in 2017. Indonesian Journal of Health Policy (JJKI), 6(4), 174–183. https://doi.org/10.22146/jkki.v6i4.26438
Dulac, N., Leveson, N., Zipkin, D., Friedenthal, S., Cutcher-Gershenfeld, J., Carroll, J., & Barrett, B. (2005). Using system dynamics for safety and risk management in complex engineering systems. Proceedings of the 37th Winter Simulation Conference. Orlando, FL, USA. https://doi.org/10.1109/WSC.2005.1574392
Evans, D. B., & Elieen, C. (2010). Health Systems Financing and the Path to Universal Coverage. SciELO Public Health.
Farhud, D. D. (2015). Impact of lifestyle on health. Iranian Journal of Public Health, 44(11), 1442. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4703222/
Garrido, M. V., Zentner, A., & Busse, R. (2011). The effects of gatekeeping: A systematic review of the literature. Scandinavian Journal of Primary Health Care, 29(1), 28–38. https://doi.org/10.3109/028133x20.2010.537015
Georgiadis, P., & Besio, M. (2008). Sustainability in electrical and electronic equipment closed-loop supply chains: A system dynamics approach. Journal of Cleaner Production, 16(15), 1665–1678. https://doi.org/10.1016/j.jclepro.2008.04.019
Gowing, L. R., Ali, R. L., Allsop, S., Marsden, J., Turf, E. E., West, R., & Witton, J. (2015). Global statistics on addictive behaviours: 2014 status report. Addiction, 110(6), 904–919. https://doi.org/10.1111/add.12899
Grindo, M., & Zeid, M. (2019). A system dynamics-based model to implement the Theory of Constraints in a healthcare system. Simulation, 95(7), 593–605. https://doi.org/10.1177/0037547917788853
Grösser, S., & Techn, D. (2005). Modeling the health insurance system of Germany: A system dynamics approach. Proceedings of the 23rd International Conference of the Systems Dynamics Society. Boston, USA.
Health, B. (2016). 2015 BPJS Health Financial Report, translated from Laporan Keuangan BPJS Kesehatan Tahun 2015. BPJS Kesehatan, Indonesia
Health, B. (2018). Program Management Report and 2017 Social Health Insurance Financial Report, translated from Laporan Pengelolaan Program dan Laporan Keuangan Jaminan Kesehatan Sosial Tahun 2017. BPJS Kesehatan, Indonesia

Page 27 of 33
Homer, J. B., & Hirsch, G. B. (2006). System dynamics modeling for public health: Background and opportunities. *American Journal of Public Health, 96*(3), 452–458. https://doi.org/10.2105/AJPH.2005.063059

Kemenkes, R. (2012). *National Referral System Guidelines*. Directorate General of Health Efforts at the Indonesian Ministry of Health.

Kleijnen, J. P. (1995). Verification and validation of simulation models. *European Journal of Operational Research, 82*(1), 145–162. https://doi.org/10.1016/0377-2217(94)00016-6

Kresojevic, B., & Gajic, M. (2019). Application of the T-Test in Health Insurance Cost Analysis: Large Data Sets. *Economics, 7*(2), 157–167. https://doi.org/10.2478/eokl-2019-0024

Kurniawtyang, D., Santosa, B., & Siswanto, N. (in press). A system dynamic to reforming of the health care sector in the Indonesian National Health Insurance System program. *International Journal of Industrial and Systems Engineering*.

Kurniawtyang, D., Santosa, B., & Siswanto, N. (2019). Financial Strategy Model for Social Health Insurance in Indonesia using Simulation. *IOP Conf. Ser. Environ. Syst. Materials Science and Engineering, Semarang, Central Java, Indonesia*. https://doi.org/10.1088/1757-899X/598/1/012118

Kurniawtyang, D., Santosa, B., & Siswanto, N. (2019b). System dynamics simulation to determine financial strategy for social health insurance in Indonesia. *Journal of Physics: Conference Series*. Medan, North Sumatera, Indonesia. https://doi.org/10.1088/1742-6596/1230/1/012047

Kurniawtyang, D., Santosa, B., & Siswanto, N. (2020). A System Dynamics for Financial Strategy Model Assessment in National Health Insurance System. *Proceedings of the 2020 2nd International Conference on Management Science and Industrial Engineering, Osaka, Japan*. https://doi.org/10.1145/3396743.3396754

Li, M., Zhang, Y., Lu, Y., Yu, W., Nong, X., & Zhang, L. (2019). Factors influencing two-way referral between hospitals and the community in China: A system dynamics simulation model. *Simulation, 94*(9), 765–782. https://doi.org/10.1177/0037549717741349

Luti, I., Hasanbasri, M., & Lazuardi, L. (2013). Government Policy in Improving Health Referral System in Riau Islands Region District in Lingga District Province of Riau Archipelago. *Indonesian Journal of Health Policy (JIKKI), 1*(1), 24–35. https://doi.org/10.22146/jikki.v1i1.3072

Mahendra, A., Trisnantoro, L., Listyadewi, S., Soewondo, P., Marthias, T., Harimurti, P., & Prawira, J. (2017). The Republic of Indonesia Health System Review. *Health Systems in Transition, 7*(1), 1–328. https://www.pubs.who.int/iris/bitstream/handle/10665/254716/9789290225164-eng.pdf

Maryati, R., & Ellya, J. (2019). Mental Hazard on Public Health Insurance: Evidence from BPJS in Indonesia. *International Journal of Innovative Technology and Exploring Engineering (IJITEE), 8*(7C2), 479–482. https://www.ijitee.org/wp-content/uploads/papers/v8i7c2/G10390587C219.pdf

Mas’udin. (2017). Identification of Financial Problems in the National Health Social Security, translated from Identifikasi Permasalahan Finansial Pada Jaminan Sosial Kesehatan Nasional. *Artha Infra, 1*(2), 111–119. https://doi.org/10.31092/jia.v1i2.142

McGuire, T. G., Newhouse, J. P., Normand, S.-L., Shi, J., & Zuvekas, S. (2014). Assessing incentives for service-level selection in private health insurance exchanges. *Journal of Health Economics, 35*(1), 47–63. https://doi.org/10.1016/j.jhealeco.2014.01.009

Ogunmibi, M. (2018). Impact of Claims Management on the Profitability of Nigerian Insurance Company: An Empirical Study of the Non-Life Insurance Sector. *SSRN, 1*(1), 1–35. http://dx.doi.org/10.2139/ssrn.3126220

PP. (2008). Government Regulation of the Republic of Indonesia Number 65 of 2008 about The Second Change to Government Regulation Number 32 of 1979 about The Termination of Civil State Employees, translated from Peraturan Pemerintah Republik Indonesia Nomor 65 Tahun 2008Tentang Perubahan Kedua Atas Peraturan Pemerintah Nomor 32 Tahun1979Tentang Pemberhentian Pegawai Negeri Sipil. Lembaga Negara Republik Indonesia. https://peraturan.kpk.go.id/Home/Detail/4892/pp-no-65-tahun-2008

PP. (2012). Government Regulation Number 101 of 2012 Regarding Recipients of Health Guarantee Fee Assistance, translated from Peraturan Pemerintah Republik Indonesia Nomor 101 Tahun2012Tentang Penerima Bantuan Iuran Jaminan Kesehatan. Lembaga Negara Republik Indonesia. https://web.persi.or.id/images/regulars/pp/pp1012012.pdf

PP. (2018). Presidential Regulation Number 82 of 2018 concerning Health Insurance, translated from Peraturan Presiden Nomor 82 Tahun2018Tentang Jaminan Kesehatan. Lembaga Negara Republik Indonesia. https://jdih.kemenkeu.go.id/fullText/2018/82TAHUN2018PERPPRES.pdf

Qi, Y., Shi, X., & Shi, C. (2015). A system dynamics model for simulating the logistics demand dynamics of metropolitans: A case study of Beijing, China. *Journal of Industrial Engineering and Management, 8*(3), 783–803. https://doi.org/10.3926/jiem.1325

Rod, F. H., & Rowzon, S. M. (2018). Designing a hybrid system dynamic model for analyzing the impact of strategic alignment on project portfolio selection. *Simulation Modelling Practice and Theory, 89*(1), 175–194. https://doi.org/10.1016/j.simpat.2018.10.001

Romadhan, A. A., Rahmadi, A. R., & Djuhaeni, H. (2019). Ability and Willingness to Pay Premium in the Framework of National Health Insurance System. *Althea Medical Journal, 2*(4), 502–505. https://doi.org/10.15850/amj.v2n4.635

Saifuddin, A. B. (2002). Buku panduan praktek pelayanan kesehatan masyarakat di Indonesia. Yayasan Bina Pustaka Sarwono Prawiroharjo.

Sargent, R. G. (2013). Verification and validation of simulation models. *Journal of Simulation, 7*(1), 12–24. https://doi.org/10.1057/js.2012.20

Scutchfield, F. D., & Keck, C. W. (2003). *Principles of public health practice*. Cengage Learning.

Sriwijaya, W. (2008). System dynamics modeling. An alternative method for budgeting. *Value in Health, 11*(1), S115–S123. https://doi.org/10.1111/j.1524-733X.2008.00375.x

Sterman, J. (2002). System Dynamics: Systems thinking and modeling for a complex world. *Massachusetts Institute of Technology (MIT) Libraries*, 1(5), 1–29. http://hdl.handle.net/1721.1/201741

Sterman, J. (2010). Business dynamics. *Irwin/McGraw-Hill c2000.

Thabryani, H. (2008). Politics of National Health Insurance of Indonesia: A New Era of Universal Coverage. 7th European conference on health economics. Rome.
Wang, X., Sun, Y., Mu, X., Guan, L., & Li, J. (2015). How to improve the equity of health financial sources? Simulation and analysis of total health expenditure of one Chinese province on system dynamics. International Journal for Equity in Health, 14(1), 73. https://doi.org/10.1186/s12939-015-0203-x

Wati, H., & Thabrany, H. (2016). Comparison of Catastrophic Disease Claims of Participants in National Health Insurance in DKI Jakarta and East Nusa Tenggara Provinces in 2014, translated from Perbandingan Klaim Penyakit Katastropik Peserta Jaminan Kesehatan Nasional di Provinsi DKI Jakarta dan Nusa Tenggara Timur Tahun 2014. Jurnal Ekonomi Kesehatan Indonesia, 1(2), 1–10. https://doi.org/10.7454/eki.v1i2.1771

West, R. (2017). Tobacco smoking: Health impact, prevalence, correlates and interventions. Psychology & Health, 32(8), 1018–1036. https://doi.org/10.1080/08870446.2017.1325890

Widiastuti, I. (2018). Services of the Social Security Organizing Agency (BPJS) in Health in West Java, translated from Pelayanan Badan Penyelenggara Jaminan Sosial (BPJS) Kesehatan di Jawa Barat. Public Inspiration: Jurnal Administrasi Publik, 2(2), 91–101. https://www.ejournal.warmadewa.ac.id/index.php/public-inspiration/article/view/801

Wolstenholme, E. (1999). A patient flow perspective of UK Health Services: Exploring the case for new “intermediate care” initiatives. System Dynamics Review: The Journal of the System Dynamics Society, 15(3), 253–271. https://doi.org/10.1002/(SICI)1099-1727(199923)15:3<253::AID-SDR172>3.0.CO;2-P

Wu, D., Yu, F., & Nie, W. (2018). Improvement of the reduction in catastrophic health expenditure in China’s public health insurance. PloS One, 14(2), e0213243. https://doi.org/10.1371/journal.pone.0194915

Yorucu, V. (2003). The analysis of forecasting performance by using time series data for two Mediterranean islands. Review of Social, Economic, and Business Studies, 2(9), 175–196. https://www.researchgate.net/profile/Vedat-Yorucu/publication/255584205_The_Analysis_of_Forecasting_Performance_by_Using_Time_Series_Data_for_Two_Mediterranean_Islands/links/56a52c3b08ae232fb2079a3c/The-Analysis-of-Forecasting-Performance-by-Using-Time-Series-Data-for-Two-Mediterranean-Islands.pdf

Zweifel, P. (2007). The Theory of Social Health Insurance. Foundations and Trends in Microeconomics, 3(3), 561. https://doi.org/10.1561/0700000004
## Appendix 1 Source for each parameter value (in alphabetical order)

| No | Variables | Sources |
|----|-----------|---------|
| 1  | Indonesia’s income | 2014–2035  
Population’s salary | https://www.bappenas.go.id/files/5413/9148/4109/Prayeksi_Penduduk_Indonesia_2010-2035.pdf |
|     | Economic growth rate |  
Salaries of each population |  
Total of each population |  
Birth |  
Death | |
| 2  | Total of each customer’s category | 2014  
2015  
2016  
2017  
2018  
2019 | https://www.kemkes.go.id/resources/download/pusdatin/profil-kesehatan-indonesia/profil-kesehatan-indonesia-2014.pdf  
https://www.kemkes.go.id/resources/download/pusdatin/profil-kesehatan-indonesia/profil-kesehatan-Indonesia-2015.pdf  
https://pusdatin.kemkes.go.id/resources/download/pusdatin/profil-kesehatan-indonesia/Profil-Kesehatan-Indonesia-2016.pdf  
https://pusdatin.kemkes.go.id/resources/download/pusdatin/profil-kesehatan-indonesia/Data-dan-Informasi_Profil-Kesehatan-Indonesia-2017.pdf  
https://pusdatin.kemkes.go.id/resources/download/pusdatin/profil-kesehatan-indonesia/PROFIL KESEHATAN_2018_1.pdf  
https://pusdatin.kemkes.go.id/resources/download/pusdatin/profil-kesehatan-indonesia/Profil-Kesehatan-indonesia-2019.pdf |
| 3  | Premium amount of each customer’s category | 2014–2017 |  
2018 |  
2020 | https://peraturan.bpk.go.id/Home/Details/41481/perpres-no-111-tahun-2013  
https://jdih.kemenkeu.go.id/fullText/2018/82TAHUN2018PERPRES.pdf  
https://peraturan.bpk.go.id/Home/Details/136650/perpres-no-64-tahun-2020 |
| 4  | Premium income | 2014  
Income | 2015  
Other income |  
All health care costs |  
Other cost |  
Health cases in FKTP |  
Health cases in FKRTL | 2017  
2018  
2019 | https://bpjs-kesehatan.go.id/bpjs/dmdocuments/8d1f305004c42d1a97177226dcd7e2c0.pdf  
https://bpjs-kesehatan.go.id/bpjs/dmdocuments/1ab1ec2a01a063cb2e932f07a9c5bf.pdf  
https://bpjs-kesehatan.go.id/bpjs/dmdocuments/8d1c9c3ff7ad4afca8f0657b0b399f8.pdf  
https://bpjs-kesehatan.go.id/bpjs/dmdocuments/9e944f8dct27adb383a13e29d49d5.pdf |

Kurnianingyasa et al., Cogent Engineering (2021), 8: 1938368  
https://doi.org/10.1080/23311916.2021.1938368
### Appendix 2 Model equations

#### Stock equation

| Name                      | Equation                                                                 | Initial value (t = 0) | Units            |
|---------------------------|--------------------------------------------------------------------------|-----------------------|-----------------|
| Population                | Birth-(Death+Non-salary worker population +Non-employees population +Salary worker population+Poor population) | 252,200,000           | People          |
| Customer                  | (Non-salary worker population+Non-employees population+Salary worker population+Poor population)-(Non-customer+PBI+PBPU+BP) | 0                     | People          |
| Population’s salary       | Population’s salary(t-1)+Economic growth rate                             | 31,308,860            | IDR/People      |
| Total of RB patients to FKTP | RB patients to FKTP in—RB patients to FKTP out                           | 0                     | People          |
| PBI premium amount        | PBI premium amount(t-1) +Increase the amount of PBI premium              | 0                     | IDR/(Months*People) |
| PPU premium amount        | PPU premium amount(t-1)=Increase the amount of PPU premium              | 0                     | IDR/(Months*People) |
| PBPU premium amount       | PBPU premium amount(t-1)+Increase the amount of PBPU premium             | 0                     | IDR/(Months*People) |
| BP premium amount         | BP premium amount(t-1)+Increase the amount of BP premium                 | 0                     | IDR/(Months*People) |
| Fund inventory            | Income-Expense                                                            | 0                     | IDR             |

#### Flow equation

| Name                      | Equation                                                                 | Units            |
|---------------------------|--------------------------------------------------------------------------|-----------------|
| Birth                     | (*"Non-customers birth"+Customers birth)                                 | People/Years    |
| Death                     | (*"Non-customers death"+Customers death)                                 | People/Years    |
| Poor population           | [INT("% of customer""% of poor population""Population")]                   | People/Years    |
| Salary worker population  | [INT("% of customer""Population""% of salary worker population")]         | People/Years    |
| Non-employees population  | [INT("% of non-employees population""% of customer")]                   | People/Years    |
| Non-salary worker population | [INT(Population"% of non-salary worker population"% of customer")]  | People/Years    |
| PBI                       | [INT("% of PBI""Customer)]                                              | People/Years    |
| PPU                       | [INT("% of PPU""Customer)]                                              | People/Years    |
| PBPU                      | [INT("% of PBPU""Customer)]                                             | People/Years    |
| BP                        | [INT("% of BP""Customer)]                                               | People/Years    |
| Non-customer              | [INT(1-("% of PBI""+"% of PPU""+"% of PBPU""+"% of BP")"Customer)]       | People/Years    |
| Economic growth rate      | [INT(("GDP (t + 1)""-"GDP (t)"")/"GDP (t)"")*Population’s salary)]     | IDR/(People*Years) |
| RB patients to FKTP in    | "FKRTL-1 patients referred back" +"FKRTL-2 patients referred back"     | People/Years    |
| Increase the amount of PBI premium | IF INT(Health costs used by PBI/(PBI patients *(Months/12))) >PBI premium amount AND Fund inventory ≤ OTHEN (INT(Health costs used by PBI/(PBI patients *(Months/12))))-PBI premium amountELSE 0 | IDR/(People*Months)/Years |
| Increase the amount of PPU premium | IF INT(Health costs used by PPU/(PPU patients *(Months/12))) >PPU premium amount AND Fund inventory ≤ OTHEN (INT(Health costs used by PPU/(PPU patients *(Months/12))))-PPU premium amountELSE 0 | IDR/(People*Months)/Years |
| Increase the amount of PBPU premium | IF INT(Health costs used by PBPU/(PBPU patients *(Months/12))) >PBPU premium amount AND Fund inventory ≤ OTHEN (INT(Health costs used by PBPU/(PBPU patients *(Months/12))))-PBPU premium amountELSE 0 | IDR/(People*Months)/Years |
| Increase the amount of BP premium | IF INT(Health costs used by BP/(BP patients *(Months/12))) >BP premium amount AND Fund inventory ≤ OTHEN (INT(Health costs used by BP/(BP patients *(Months/12))))-BP premium amountELSE 0 | IDR/(People*Months)/Years |

(Continued)
(Continued)

| Income                  | Premium incomes+Other incomes | IDR/Years |
|-------------------------|-------------------------------|----------|
| Expense                 | Other cost+(Health cost*Years) | IDR/Years |

**Auxiliary equation**

| Name                    | Equation                                                                 | Units   |
|-------------------------|--------------------------------------------------------------------------|---------|
| Indonesia’s income      | Population*Population's salary                                           | IDR     |
| Non-salary worker salary| INT(Indonesia’s income*“% of non-salary worker salary”)/“Non-salary worker population” | IDR/People |
| FKTP patients           | INT(Customer*“% of FKTP patients”)+Total of RB patients to FKTP           | People  |
| FKRTL-1 patients        | INT(FKTP patients*“% of FKTP patients referred”)                          | People  |
| FKRTL-2 patients        | INT(FKRTL −1 patients*“% of FKRTL −1 patients referred”)                 | People  |
| Claim cost              | INT(“Average of CBGs cost in FKRTL −1”*“FKRTL −1 patients”)+ (“Average of CBGs cost in FKRTL −2”*“FKRTL −2 patients”)) | IDR/Years |
| Capitation cost         | INT(Customer*Average of capitation cost)                                 | IDR/Years |
| Non-capitation cost     | INT(FKTP patients*“Average of non-capitation cost”)                      | IDR/Years |
| Health cost             | Capitation cost+ “Non-capitation cost”+Claim cost                         | IDR/Years |
| Health cost PBI         | INT(Health costs PBI*“% of health costs PBI”)                            | IDR/Years |
| Health cost PPU         | INT(Health costs PPU*“% of health costs PPU”)                            | IDR/Years |
| Health cost PBPU        | INT(Health costs PBPU*“% of health costs PBPU”)                          | IDR/Years |
| Health cost BP          | INT(Health costs BP*“% of health costs BP”)                              | IDR/Years |
| Premium incomes from PBI customer | INT(PBI premium amount*Months*PBI)                                      | IDR/Years |
| Premium incomes from PPU customer | INT(PPU premium amount*Months*PPU)                                      | IDR/Years |
| Premium incomes from PBPU customer | INT(PBPU premium amount*Months*PBPU)                                    | IDR/Years |
| Premium incomes from BP customer | INT(BP premium amount*Months*BP)                                        | IDR/Years |
| Premium income          | Premium income from PBPU customer+Premium income from BP customer+Premium income from PBI customer | IDR/Years |
| ATP                     | INT(0.05 (“% of non-food expenditure of non-salary worker salary” “Non-salary worker salary”))/Months |         |

**Parameters equation**

| Name                    | Value (Basic Scenario)                                                                 | Units   |
|-------------------------|----------------------------------------------------------------------------------------|---------|
| Non-customer birth      | [4,531,900 ... 4,439,600]                                                            | People  |
| Non-customer death      | [1,423,400 ... 3,536,100]                                                            | People  |
| GDP                     | [8.262e+15 ... 5.7149e+16]                                                            | IDR/People |
| Initial amount of PBI premium | 19,225                                                                                 | IDR/(Months*People) |
| Initial amount of PPU premium | 38,843                                                                                 | IDR/(Months*People) |
| Initial amount of PBPU premium | 59,500                                                                                 | IDR/(Months*People) |
| Initial amount of BP premium | 73,252                                                                                 | IDR/(Months*People) |
| Months                  | 12                                                                                     | Months  |
| Other income            | [793,959,000,000 ... 11,225,840,000,000]                                              | IDR/Years |
| Other cost              | [2,164,263,000,000 ... 24,809,900,000,000]                                            | IDR/Years |
| Inflation cost          | {0.023 ... 0.985}                                                                      | Dimensionless |
