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Dynamic Simulation of Doctor Needs in East Java Province By Using iThink

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Abstract

This study compares the calculation of doctor needs in East Java Province using two dynamic simulations, namely iThink and Python. The purpose of this study is to identify differences in results between the two simulation platforms in estimating the need and availability of doctors based on population growth and the number of medical graduates. The methodology used involves modeling population dynamics and the flow of active doctors by considering the inflow of medical students and the WHO ratio. The results of the iThink simulation show an increase in the number of active doctors from 42,000 to 63,793 in 10 years, approaching the ideal WHO ratio, while the Python simulation shows a significant gap between the need and the number of doctors, with the need reaching 257,680 doctors in 2029, but the number of active doctors only reaching 21,686. This difference is due to variations in the methodology and approach of each platform. The conclusion of this study shows the importance of policy interventions to meet the need for doctors in the future and reduce the gap between the need and availability of doctors.

Keywords: doctor needs, dynamic simulation, iThink, Python, East Java, health policy.

1. Introduction

Health is a valuable asset that affects every aspect of human life (Suiraoka, IP, et al., 2024). In this case, Health Human Resources (HR) are an important factor in the health sector, especially in supporting the implementation of health services (Rafli, MM, 2024). The distribution and number of doctors in Indonesia, including in East Java Province, are still major challenges. Based on projections, the need for doctors in East Java continues to increase along with population growth, changes in disease patterns, and increasing public expectations of health services.

Accurate planning is needed to ensure the availability of sufficient medical personnel to support the provision of health services (Rafli, MM, 2024). However, commonly used planning methods often fail to address various factors that affect the need for doctors, including population growth and the replacement rate of retired doctors (Rafli, MM, 2024). Therefore, a more adaptive and holistic approach is needed to analyze the need for doctors in the future.

Dynamic models are models that can be developed to understand changes in demand and supply that change over time (Mirwan, M., & Maulidah, A., 2022). In the dynamic system approach, the system is first described through a causal loop diagram. The Causal Loop Diagram model is one of the models used to solve problems with a systems approach, which takes into account the dynamic complexity of the system or to support dynamic system analysis (Widiana & Maharani., 2019). In this study, two simulation tools, namely I-Think and Python, were used to compare the calculation of doctor needs in East Java Province.

This study aims to examine the distribution of doctors in East Java by considering related factors, such as population, number of prospective doctors currently studying, graduation rate, doctor retirement, and availability of health facilities in the area. Health workers who play a role in efforts to improve health can work in health service facilities, both at the primary and advanced levels (Law of the Republic of Indonesia Number 17 of 2023, 2023). With this approach, it is hoped that a more accurate and relevant analysis can be produced, so that it can help support decision making in meeting the needs of medical personnel in East Java Province.

2. Literature review

2.1 Simulation

Simulation is the process of creating a mathematical or logical model of a real system, then conducting experiments on the model using a computer to describe, explain, and predict the behavior of the system (Ahdan & Sari, 2020). According to Harrell, from a simulation perspective, simulation consists of entities, activities, resources, and controls. These elements define who, what, where, when, and how the process takes place in the entity.

2.2 Dynamic System

Dynamic systems are a method used to understand various complex problems (Kurnia, M., et al., 2023). This model has the main characteristics of changes in system behavior that are dynamic over time, as well as the existence of feedback relationships between entities in the system (Karima, HQ, et al., 2022). The purpose of dynamic systems is to explain how various variables in a system interact with each other and how the system responds to changes in these variables (Saleh, IRC, 2019).

2.3 Causal Loop Diagram (CLD)

Causal Loop Diagram (CLD) is a diagram that describes a cause-and-effect relationship, which is used to describe the structure of mutual influence in the modeled system (Ramadhania, S., et al., 2024). CLD focuses on the cause-and-effect relationship between system elements, which are depicted in the form of a diagram with curved lines with arrows to connect one element to another (Saleh. IRC, 2019). In CLD, cause-and-effect relationships can be positive or negative. The relationship is considered positive when both nodes experience changes in the same direction, while the relationship is considered negative if both nodes change in opposite directions (Anggraini & Alfi, 2019).

2.4 Stock and Flow Diagram (SFD)

Stock Flow Diagram is a diagram used to describe the relationship between variables and is generally applied in dynamic system methods (Putri & Butar., 2021). Flow variables are variables that function to increase the value of state variables (inflow) or decrease them (outflow) (Indrawati, CD, et al., 2024). In the diagram, there are exogenous variables (known) and endogenous variables (calculated).

2.5 SoftwareiThink

According to Barry Richmond, iThink allows users to depict relationships between elements in a system using visual symbols such as stocks, flows, and connectors. iThink helps users simulate and analyze the behavior of a system over time, taking into account the dynamic interactions between the variables in the system.

2.6 Dimension Analysis

Dimensional analysis is a method used to understand the relationship between the dimensions of independent variables and the dimensions of dependent variables that operationally influence each other on each variable (Handayani, E., et al., 2017). In this case, dimensional analysis also studies each dimension of the independent variable that affects the dependent variable (Soraya, QFE, 2019).

2.7 Education Medical

In Law of the Republic of Indonesia Number 20 of 2013, Medical Education is a conscious and planned effort in formal education consisting of academic education and professional education at the higher education level whose study programs are accredited to produce graduates who have competence in the field of medicine or dentistry. Medical science is an effort to understand, maintain, and manage human health in a biosocial context, both as individuals and as part of society (Yasni & Anwar., 2023). In addition, medical science also includes studies on health maintenance, as well as prevention, treatment, and management of diseases (Salsabela, D., 2022).

3. Research methods

The research method for the Comparison of Calculation of Doctor Needs in East Java Province with Dynamic Simulation using I-Think and Python follows the stages as listed in Figure 1 below.

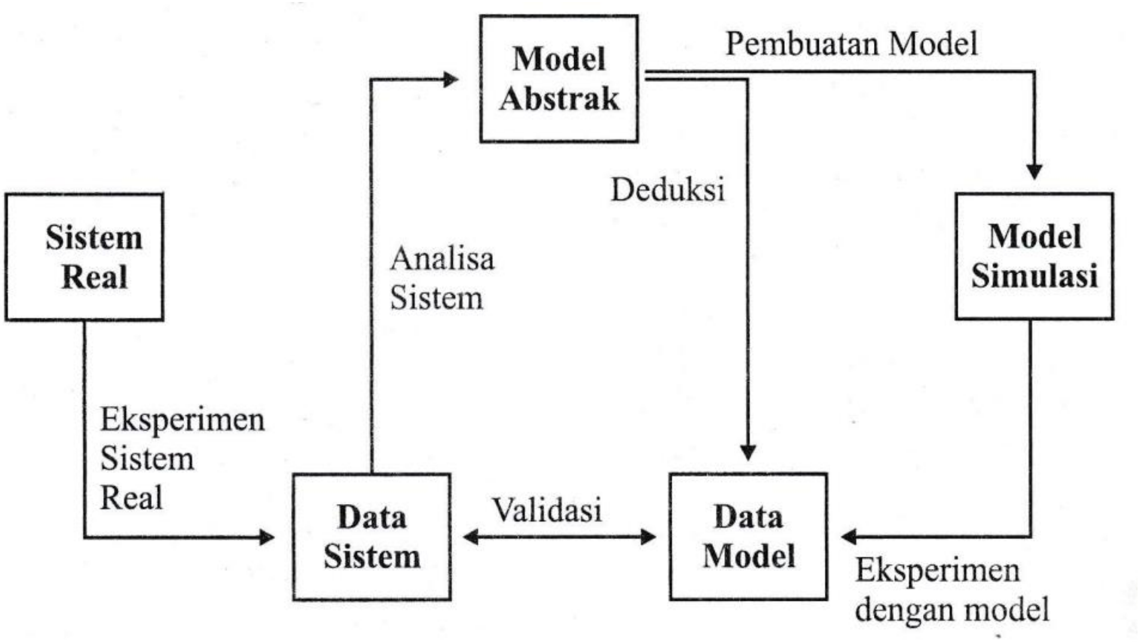


Figure 1: Simulation Method

3.1 Real System

East Java Province with a population of 42 million people faces a significant gap between the need for doctors and the number of doctors available. Currently, there are only 21,000 doctors available, while the ideal need is 42,000 doctors based on the World Health Organization (WHO) ratio standard of 1:1000. This challenge is exacerbated by the graduation rate of prospective doctors of only 60%, the retirement rate of doctors of 1.5% per year, and increasing population growth. With a birth rate of 15 per 1000 and a death rate of 6 per 1000, the population increases every year, so the need for doctors is increasing. This study aims to analyze the dynamics of the system using a dynamic systems approach to understand the relationship between population, prospective doctors, the need for doctors, and the supply of doctors, as well as evaluate policies that can balance the need and supply of doctors in the future.

3.2 System Data

The system data used in this study is quantitative data that supports the creation of dynamic simulation models. The elements used are as follows.

a) Population, this data includes the total population in East Java Province which continues to grow every year, influenced by birth and death rates.
b) Prospective Doctors, this data includes the number of prospective doctors currently studying medicine, influenced by the graduation rate and the number of applicants.
c) Number of Doctors, this data includes the number of doctors available to meet health service needs, which is influenced by graduation and retirement rates.
d) Doctor Needs, this data describes the number of doctors needed based on a standard ratio of 1:1000, which increases along with population growth.

3.3 Abstract Model

The abstract model for this study describes the dynamic relationships between variables in the system, namely Population, Prospective Doctors, Number of Doctors, and Need for Doctors. This model describes how these variables influence each other in the long term. For example, an increase in the population influenced by births will increase the need for doctors, while the number of doctors is influenced by the graduation rate of prospective doctors and the retirement rate of doctors. This model also considers external factors such as health policies that can affect the supply and distribution of doctors.

3.3 Simulation Model

This simulation model was built using iThink software to model the relationships between elements in a dynamic system. Stock and Flow Diagrams were used to illustrate changes in system variables, such as population growth, doctor graduations, doctor retirements, and doctor demand. The model was then implemented in Python to estimate changes over time and to test various policies that could be implemented to address the gap between doctor demand and supply.

3.4 Data Model

The data used in this simulation model includes historical data on population, number of doctors, graduation rates of prospective doctors, retirement rates of doctors, and birth and death rates. These data are used to calibrate the model and ensure that the simulation reflects the conditions in East Java Province. In addition, data on health policies implemented in the past are also used to evaluate the impact of these policies on the supply of doctors.

3.5 Validation

The validation process is carried out by comparing the simulation results with existing empirical data to ensure that the model can accurately represent the dynamics of the system. Validation also includes sensitivity testing of variables that have a significant influence, such as the graduation rate and retirement rate of doctors. The results of the validated simulation are expected to provide a more accurate picture of the needs and distribution of doctors in the future, as well as provide recommendations for more effective health policies.

4. Results and Discussion

4.1 Simulation Model ResultsDynamic with iThink

4.1.1 Black box diagram

The Black-box diagram is designed to provide a systematic overview of the process of managing the needs of doctors in East Java Province. This model uses a dynamic simulation approach to process various inputs, both controlled and uncontrolled, to produce relevant outputs. The simulation process and its detailed results can be seen in Figure 2 below.

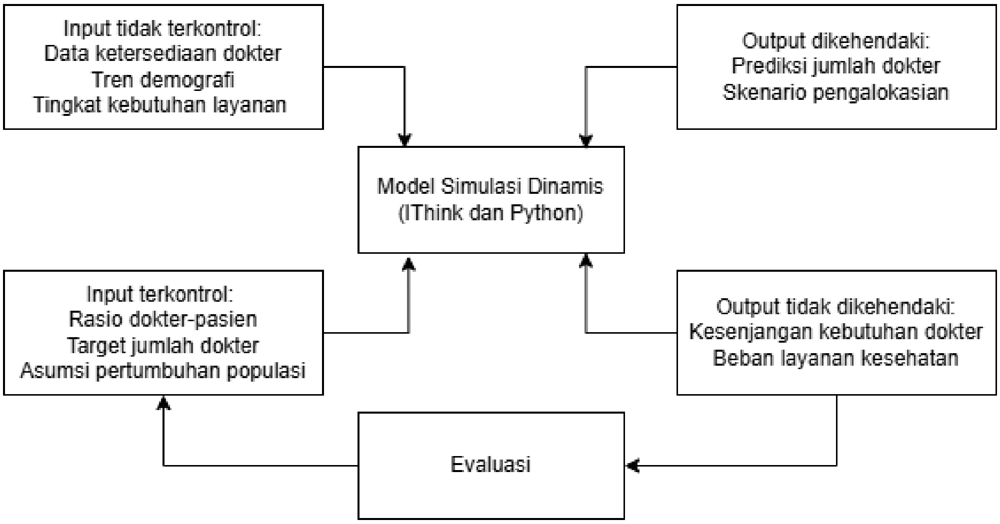


Figure 2: Black box diagram

This dynamic simulation model is simulated from controlled inputs such as doctor-patient ratio, target number of doctors, and population growth assumptions. These inputs are variables that can be set or modified to achieve certain goals in health workforce management.

In addition, the model also considers uncontrolled inputs, namely data on doctor availability, demographic trends, and the level of need for health services. These inputs are external and difficult to intervene directly, but greatly affect the simulation results.

By processing these inputs, the dynamic simulation model produces two types of output, namely:

- The desired output is a prediction of the number of doctors needed and a scenario for optimal allocation of medical personnel to meet health service needs.
- Unintended outputs, such as gaps in the need for doctors due to a lack of available medical personnel and the burden on health services that can impact the quality of services.

This simulation process is carried out using software such as iThink for dynamic system modeling and Python, implemented through Google Colab, for data analysis and simulation. The simulation results are then evaluated to assess model performance, identify errors, and compare the final results to improve the effectiveness of future health workforce management strategies.

4.1.2 CLD

Causal Loop Diagram using dynamic system model is formed by considering factors that can affect the need for doctors in East Java Province. After analysis, several factors that affect the need for doctors include population, number of doctors, need for doctors, and prospective doctors, which can be seen in detail in Figure 3.

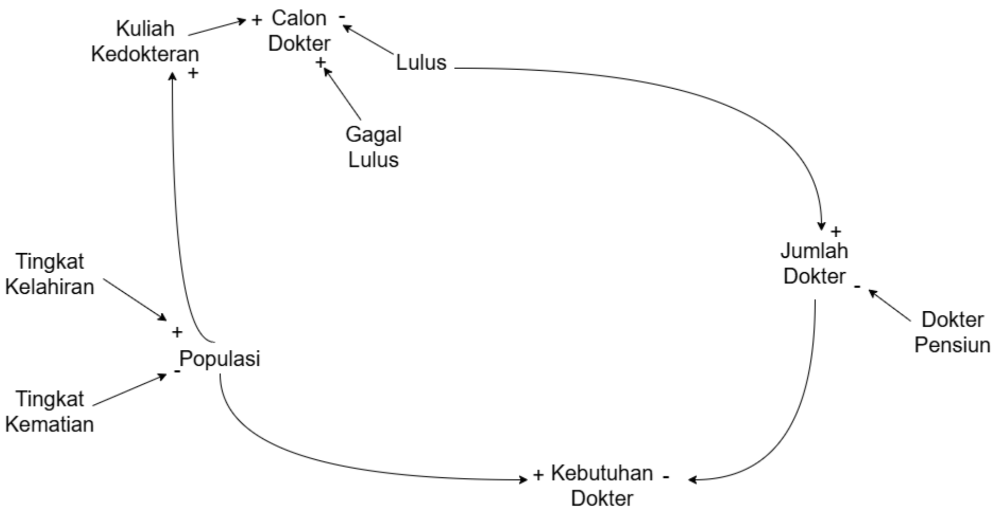


Figure 3: Causal Loop Diagram

a. Population is influenced by birth rates (+) and deaths (-), where population growth drives an increase in the need for doctors based on a ratio of 1:1000 population.
b. The number of prospective doctors increases through medical school (+), but the graduation rate is only 60%, limiting the supply of doctors.
c. The number of doctors increases due to the graduation of prospective doctors (+) but decreases due to retirement by 1.5% per year (-).
d. The need for doctors continues to increase as the population grows (+), but the number of doctors available helps reduce the gap (-).

4.1.3 SFD

In the Stock Flow Diagram to predict the need for doctors in East Java Province until 2029, consider the variables that can affect the need for doctors, as shown in Figure 4. These variables will interact with each other and influence each other.

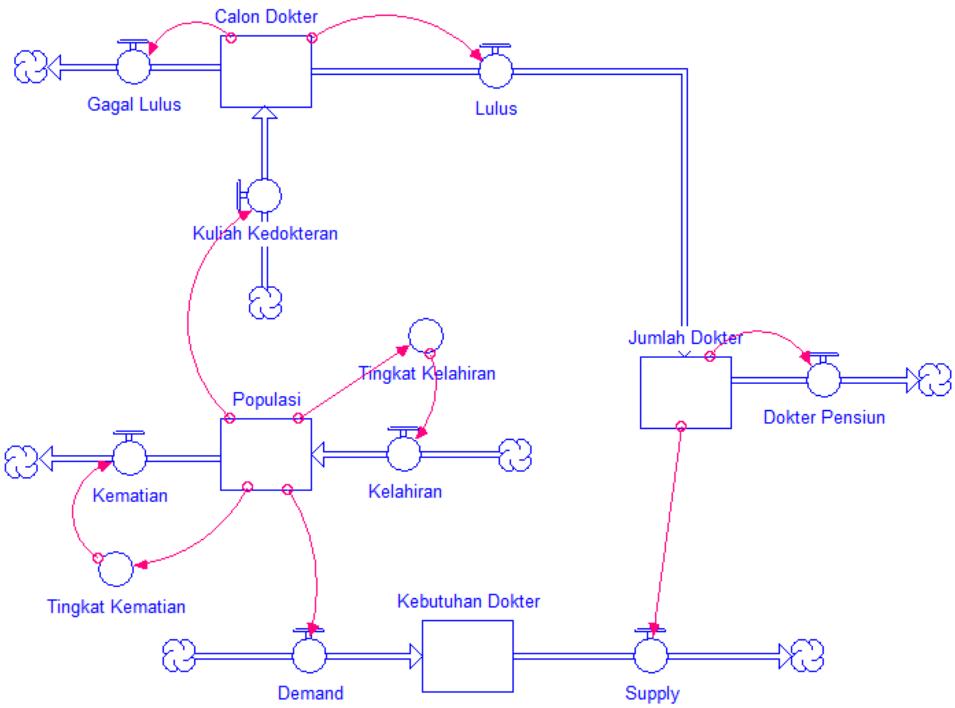


Figure 4: Stock and Flow Diagram

This simulation model uses a dynamic systems approach to analyze the relationships between population, number of doctors, doctor needs, and prospective doctors. The following is a description of the main elements in the diagram.

a. Stock
   1) Prospective Doctors, which shows the number of medical students who will increase through the inflow of Medical Studies and decrease through the outflow of Pass and Fail Pass.
   2) Number of Doctors, which represents the number of active doctors which will increase through the inflow of Graduates and decrease through the outflow of Retired Doctors.
   3) Need for Doctors, which describes the difference between the need and supply of doctors in society.
   4) Population, which shows the total human population in the system is affected by the inflow of Births and the outflow of Deaths.

b. Flow
   1) Medical College, a stream that adds prospective doctors based on a small portion of the population.
   2) Pass and Fail Pass, a flow that reduces Prospective Doctors based on the level of success and failure.
   3) Doctor Retirement, a flow that reduces the Number of Doctors based on the retirement rate.
   4) Births and Deaths, flows that influence population change.

c. Converter
   1) Birth rate is the ratio of births per 1000 population.
   2) Mortality rate is the ratio of deaths per 1000 population.
   3) Demand is the demand for doctors based on population.
   4) Supply is the supply of doctors based on the number of active doctor.

4.2 Results

4.2.1 Simulation Results on Time Table

The time table of simulation results using iThink depicts changes in population dynamics, the need for doctors, prospective doctors, and the number of doctors over ten years as shown in Figure 5.

15:11 19/12/2024 Table 1 (Untitled Table)

Years	Populasi	Kebutuhan Dokter	Calon Dokter	Jumlah Dokter
Initial	42.000.000,00	21.000,00	2.700,00	21.000,00
1	42.379.277,66	63.120,27	6.620,44	23.379,44
2	42.761.980,37	105.618,00	7.912,97	27.334,64
3	43.148.139,03	148.495,54	8.374,47	31.771,82
4	43.537.784,88	191.756,04	8.573,51	36.345,44
5	43.930.949,39	235.402,91	8.689,98	40.946,69
6	44.327.664,34	279.439,68	8.780,81	45.541,66
7	44.727.961,79	323.869,91	8.864,01	50.120,14
8	45.131.874,10	368.697,23	8.945,30	54.679,40
9	45.539.433,90	413.925,27	9.026,47	59.219,08
10	45.950.674,14	459.557,71	9.108,10	63.739,56

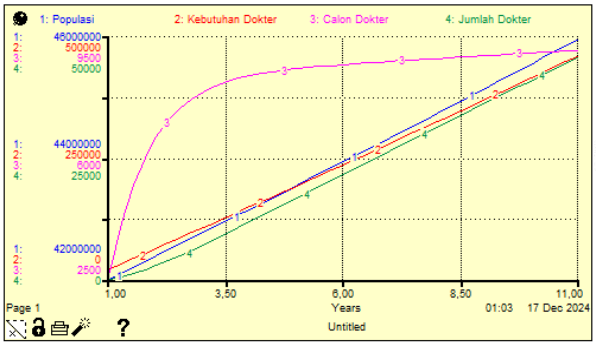
Figure 5: iThink Time Table Results

The initial population of 42 million continued to increase, reaching 45.9 million in the 10th year due to a higher birth rate than death rate. The need for doctors increased significantly from 21,000 doctors at the beginning of the year to 459,557 doctors in the 10th year, as the population grew.

The number of prospective doctors also increased from 2,700 in the early years to 9,108 in the 10th year, supported by an increase in the number of medical students. However, the number of doctors available was not able to meet the needs, only increasing from 21,000 in the early years to 63,739 doctors in the 10th year.

4.2.2 iThink and Python Simulation Visualization Results

Comparison of simulation visualization results using iThink and Python showing the estimated increase in population, need for doctors, prospective doctors, and number of doctors in East Java Province.



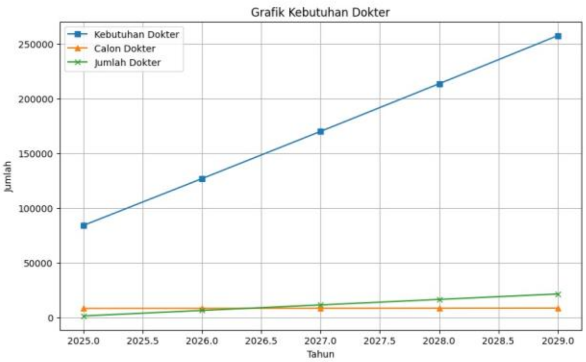


Figure 6: Visualization on iThink **Figure 7:** Visualization in Python

The simulation results conducted using I-Think and Python show a significant difference between the need and availability of doctors in East Java Province. The I-Think simulation graph shows that the need for doctors increased from 2,500 to 5,000 in 11 years. Meanwhile, in the Python simulation, the need for doctors jumped even more sharply, from 100,000 to more than 250,000 in just 4 years.

However, the availability of doctors in both simulations remains far below the number of needs. In the I-Think simulation, the number of available doctors only reaches 4,800, while in the Python simulation, the number does not reach it at all. This shows an imbalance in the growth of the number of available doctors compared to the increasing need.

In addition, the number of prospective doctors in both simulations tends to stagnate. In the I-Think simulation, the number of prospective doctors remains around 4,000, and this number is even lower in the Python simulation. This stagnation indicates limitations in the medical education system that have an impact on the low number of prospective doctors.

Overall, the simulation results show a structural gap between the increasing demand and the limited availability of doctors and prospective doctors. This highlights the major challenge in creating an adequate balance in the health care system in East Java Province.

4.2.2 Difference in Dynamic Simulation Results Between iThink and Python

The results of the dynamic simulation comparison between iThink and Python in Figure 9 show that there are differences in the percentage of results for several variables.

```
Persentase perbedaan nilai Populasi : 0.0
Persentase perbedaan nilai Kebutuhan Dokter : -5.702887860301588
Persentase perbedaan nilai Calon Dokter : -0.9000161947783966
Persentase perbedaan nilai Jumlah Dokter : -0.8361944226427174
```

Figure 8: Differences in iThink and Python Simulation Results

The difference in population values is very small, which is 0.0%. However, a more significant difference was found in the variable of doctor needs of -5.70%. Meanwhile, the difference in the number of prospective doctors and the number of doctors is relatively small, respectively -0.90% and -0.84%.

4.3 Discussion

Based on a study conducted by Laksono et al. (2020), the distribution of health workers in Indonesia faces significant challenges due to difficulties in education and training, location placement, and retention and performance of health workers. In addition, Hermawan (2019) stated that the World Health Organization (WHO) sets the Universal Health Coverage indicator with a minimum ratio of health workers of 4.45 per 1,000 population.

In this case, the distribution of health workers in East Java Province shows a significant gap between the need and availability of doctors. Currently, there are only 21,000 doctors available, while the ideal need is 42,000 doctors based on the WHO ratio standard of 1:1000. This challenge is exacerbated by the graduation rate of prospective doctors of only 60%, the retirement rate of doctors of 1.5% per year, and the increasing population growth. With a birth rate of 15 per 1,000 and a death rate of 6 per 1,000, the population is increasing every year, so the need for doctors is increasing.

This study aims to analyze system dynamics using a dynamic system approach to understand the relationship between population, prospective doctors, doctor needs, and doctor supply, and to evaluate policies that can balance the needs and supply of doctors in the future.

5. Conclussion

Based on the simulation results using i-Think, the number of doctors is expected to increase from 42,000 to 63,793 within 10 years. This is close to the ideal ratio recommended by the World Health Organization (WHO), which is 1 doctor per 1,000 residents. This simulation indicates that in meeting the need for medical personnel in the future, as long as efforts to distribute and provide doctors are carried out evenly and efficiently.

However, the simulation results using Python show a significant gap. In this simulation, the number of doctors only increased from 1,620 to 21,686, which is far from the ideal needs that continue to increase along with population growth and public expectations of health services. This difference in results is mainly due to variations in the methodology used and the functions implemented in each simulation tool.

This study emphasizes the importance of appropriate policy interventions to ensure adequate availability of doctors in the future. Policies involving more holistic and adaptive planning, as well as a more in-depth data-driven approach, are needed to balance the need for and supply of doctors.

References

Ahdan, S., & Sari, PI (2020). Development of a web application for savings and loan simulation (case study: Islamic financial institution BMT I-Risma. *Jurnal Tekno Kompak, 14 (1), 33–40.*

Anggraini, W., & Alfi, I. (2019). Application of Dynamic System Model to Analyze Demand and Availability of Electricity in Household Sector (Case Study: Special Region of Yogyakarta) (Doctoral dissertation, University of Technology Yogyakarta).

Handayani, E., & Dedi, M. (2017). The influence of marine tourism promotion and service quality on increasing the number of tourist visits to Muncar Port, Banyuwangi. *Jurnal Wira Ekonomi Mikroskil, 7(2), 151-160.*

Hermawan, H. (2019). Universal Health Coverage: Measuring Indonesia's achievements. The SMERU Research Institute.

Indrawati, CD, Pitoyo, DJ, & Murdapa, PS (2024). Systemic Approach Methodology: A Fundamental and Powerful Managerial Method That Needs to be Implemented. *JUSTER: Journal of Science and Applied, 3(1), 8-16.*

Karima, HQ, Saputra, MA, & Romadlon, F. (2022). Analysis of production capacity and demand fulfillment with dynamic system models in the cement industry. *Unistek: Journal of Education and Industrial Applications, 9(1), 11-18.*

Kurnia, M., Rusman, M., Aditya, W., & Astrina, A. (2023). Prediction of Electricity Consumption in Makassar City using Dynamic System Modeling. *ARIKA, 17(2), 66-72.*

Laksono, AD, Wulandari, RD, & Astuti, WD (2020). Analysis of doctor distribution in Indonesia. *Indonesian Journal of Health Administration, 8(1), 1-10.*

Law of the Republic of Indonesia Number 17 of 2023, Law of the Republic of Indonesia Number 17 of 2023 concerning Health (2023).

Mirwan, M., & Maulidah, A. (2022). Planning of Waste Transportation System with Dynamic Method in UPTD Tumpang. *ESEC Proceedings, 3(1), 7-14.*

Puspitasari, DI, Donoriyanto, DS, Purnamawati, E., Moenandar, S., & Widodo, LU (2021). Planning the Opening of the Medical Study Program at Upn Veteran East Java Using a Dynamic Simulation Model. *Tekmapro: Journal of Industrial Engineering and Management, 16(1), 1-12.*

Putri, AV, & Butar, MBB (2021, December). System Dynamics Analysis of Dynamic Model of Cattle Carcass Procurement at Slaughterhouse (RPH) X Using Stella 9.0 Software. 2. *In National Seminar on Industrial Engineering and Management (Vol. 1, No. 1, pp. 314-323).*

Rafli, MM (2024). Analysis of the Distribution of Doctors as Health Workers in East Java Province in 2022. *Tambusai Health Journal, 5(2), 4316-4325.*

Ramadhania, S., Rini, AS, Herdiyani, A., Gunawan, G., & Majdi, NC (2024). WORKLOAD ANALYSIS USING WORK LOAD ANALYSIS WITH SOFT SYSTEM METHODOLOGY APPROACH AT PT INDORAMA PETROCHEMICALS. *Scientific Journal of Industrial Engineering and Management, 4(1), 56-69.*

Richmond, B. (2001). An Introduction to Systems Thinking with iThink. isee systems.

Saleh, IRC (2019). Combination of Structural Equation Modeling (SEM) Method and Dynamic System Simulation to Predict Advocate Behavior Performance in Talent Management (Case Study: IKADIN Yogyakarta) (Doctoral dissertation, Universitas Islam Indonesia).

Salsabela, D. (2022). TREATMENT IN MEDICINE IN 4000-2500 BC. *NIHAIYYAT: Journal of Islamic Interdisciplinary Studies, 1(2), 219-230.*

Soraya, QFE (2019). The Influence of Motorcycle Spare Parts Delivery Service Quality and Prices that Affect Customer Satisfaction and Its Implications for Customer Loyalty: The Case of PT. Alpindo Mitra Baja Sukabumi. BUANA INFORMATIKA, 7(1), 115-127.

Suiraoka, IP, St, S., Ekawati, CJ, Putra, ES, Gz, M., Lundy, F., & Erg, M. (2024). Health Promotion. CV Rey Media Grafika.

Widiana, DR, & Maharani, KD (2019, December). Study of Solid Waste Management in Health Facilities Using Dynamic System Approach (CASE STUDY: PONOROGO CITY). In Seminar MASTER PPNS (Vol. 4, No. 1, pp. 241-252).

Yasni, Y., & Anwar, A. (2023). Integration of Science in Islam Case: Medical Science and Health Science. *Journal of Science and Technology, 5(2), 691-695.*