System Dynamics Modeling of Health Workforce Planning to Address Future Challenges of Thailand's Universal Health Coverage

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Abstract

System dynamics modeling can inform policy decisions of healthcare reforms under Thailand's Universal Health Coverage. We report on this thinking approach to Thailand's strategic health workforce planning for the next 20 years. A series of group model building sessions involving 110 participants from multi-sectors of Thailand's health systems was conducted in 2017 and 2018. Policymakers, healthcare administrators, and practitioners were facilitated to co-create a causal loop diagram that represents a shared understanding of why the demands and supplies of the health workforce in Thailand can be mismatched and a stock and flow diagrams for testing the consequences of policy options. Our model found hospital utilizations created a vicious cycle of constantly increasing demands for hospital care, and hence a constant shortage of healthcare providers. Moreover, hospital care was not designed for effectively dealing with the future demands of aging populations and prevalent chronic illness. Hence, shifting emphasis to professions that can provide primary care, intermediate care, long-term care, palliative care, and end-of-life care can be more effective. Our simulation modeling confirmed that shifting the care models to address the changing health demands can be a high-leverage policy of health workforce planning, although very difficult to implement in the short term.

Keywords: human resource for health, health workforce, strategic planning, care models, health systems performance, group model building, causal loop diagram, system dynamic modeling

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Introduction

Thailand achieved Universal Health Coverage (UHC) in 2002 after decades of healthcare infrastructure development and experimenting with several financial risk protection schemes (Tangcharoensathien, Witthayapipopsakul, Panichkriangkrai, Patcharanarumol, & Mills, 2018). Since then, every Thai citizen was covered under one of the three major health financing schemes. Even before the implementation of Thai UHC, the planning of Thailand's health workforce has been incorporated into the National Economic and Social Development Plans. Public healthcare facilities have been expanded nationwide, including the building of provincial hospitals in every province of Thailand by 1976, the development of community hospitals in every district by 1991, and the modernization of primary care centers at the sub-district level during the 1990s (Wibulpolprasert, Sirilak, Ekachampaka, & Wattanamano, 2011). Hence, historically, the national plans of workforce production and development also have focused on the providers in the public sector.

Health workforce or human resource for health (HRH) is one the building blocks of health systems, and the types and the number of healthcare providers needed in each health system are closely linked to how health care is organized on each country (Campbell et al., 2013; World Health Organization, 2007). Like many other countries, healthcare systems in Thailand have been organized since the last century in a way that makes them more responsive to acute illness. Hospitals, which are historically designed for acute care, are currently the dominant providers for the UHC beneficiaries. Policymakers of the three publicly-financed health funds have allocated most resources to providers in public hospital settings, but not in others providing in primary care, intermediate care, long-term care, palliative care, and end-of-life care. As a result, hospitals have been the major employers of healthcare providers in Thailand thus far.

More recently, a rapidly increased prevalence of non-communicable diseases and aging populations, as well as insufficient facilities specifically designed for chronic and elderly care, have limited the effectiveness of Thailand's first decade of Universal Health Coverage (Health Insurance System Research Office, 2012). This rapid change of the population's health demands could also aggravate the complex problem of inadequate health workforce domestically, which eventually can lead to equitable access to quality health care under Thai UHC. The expansion of private healthcare facilities in the private sector since the early 2000s also created a domestic "brain drain" of the health workforce, especially physicians, despite the innovative policies to retain them in the public sector.

Although Thailand has produced more healthcare workers every year, with the number of physicians or nurses per capita has been rapidly increased over the decades, many Thai UHC beneficiaries still have limited access to quality health care. Research has shown that public hospitals in Thailand produced services relatively close to their capacity given fixed inputs (Valdmanis, Kumanarayake, & Lertiendumrong, 2004). The long waiting time of patients at the outpatient department of every public hospital nationwide is self-evident for the current mismatches between supplies and demands of the health workforce in Thailand. Therefore, increasing the number of health workforce produced each year will only get us thus far.

Therefore, a more comprehensive strategic planning that includes the reforms of healthcare delivery itself is needed to address this complex problem. We aimed to analyze what causes the chronic mismatches of supply and demands for the health workforce in Thailand and to synthesize more sustainable solutions to supply population health demands in Thailand in the future adequately. Using a systems thinking approach and a structured process of group model building (GMB), we engaged with stakeholders who are embedded in a system to examine the nature of these complex problems, the pattern of system behaviors over time, and also to highlight the feedbacks within the systems. In the present study, we report on developing a whole-systems perspective of problems related to the health workforce in Thailand in the next 20 years, what causes them, and how potential systems interventions can be identified and tested by using system dynamics simulation modeling.

Method

Setting

The study was carried out as a research project by Mahidol University's Faculty of Medicine Ramathibodi Hospital, in collaboration with Thailand's Ministry of Public Health. A series of group model building (GMB) sessions were conducted in our workshops held in Bangkok and Nonthaburi, Thailand, during 2017 and 2018.

Study design and participants

The study employed systems thinking and modeling methodology based on the system dynamics approach (Forrester, 1987). We adopted five major phases of the systems thinking and modeling methodology put forth by Maani & Cavana (2007), including 1) problem structuring, 2) casual loop modeling, 3) dynamic modeling, 4) scenario planning and modeling, 5) implementation and organizational learnings. The findings from both our models were presented to high-level executives in the Ministry of Public Health for eliciting comments and feedbacks.

One hundred ten stakeholders, who are policymakers, healthcare administrators, and practitioners from multi- sectors in Thai health systems, participated in a series of our workshop. They were facilitated to co-create a causal model that can explain the mismatches between demands and supplies of the health workforce in Thailand, which progressed from connecting relevant concepts to constructing qualitative causal loop diagrams (CLDs) and quantitative stock and flow diagrams (SFDs).

Group Model Building

Using scripts from system dynamics literature, we facilitated the stakeholders by using a structured process of group model building (GMB) (Andersen & Richardson, 1997; Vennix, Andersen, Richardson, & Rohrbaugh, 1992) to engage with relevant stakeholders. First, we discussed and agreed upon the expected outcomes in the next 20 years of the national planning of the health workforce, and drawn the reference mode of such outcomes. Second, we developed a CLD with stakeholders to gain a mutual understanding of what factors caused undesirable consequences, particularly mismatches of supply and demands for the health workforce in Thailand over the decades. Third, we continued working with stakeholders to turn our insights from the CLD into an SFD and simulated the selected health systems outcomes for the next two decades (2018-2037). Lastly, we analyze the consequences of such policy options by simulating them in our system dynamic modeling.

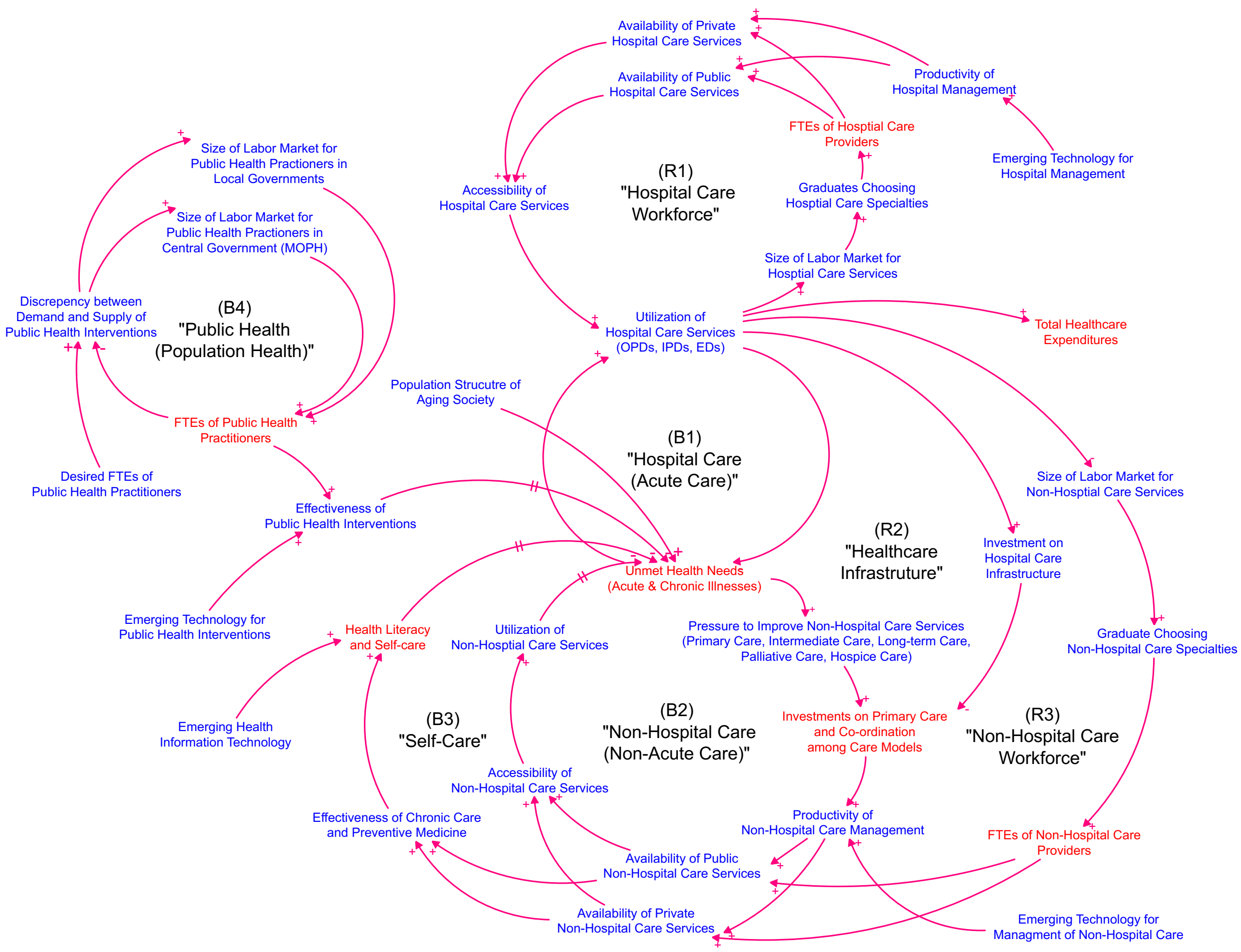

Figure 1 The causal loop diagram (CLD) of insufficiency of the health workforce in the hospital care and the non-hospital care settings of Thailand from the GMB process

Our GMB sessions produced a CLD that represents a common undersetting among participating stakeholders. The critical variables discussed in the GMB sessions include the population structure of aging society, the unmet health needs of the population, utilization of healthcare services in hospital settings, utilization of healthcare services in non-hospital settings, size of the labor market of hospital care, size of the labor market in non-hospital care, the effectiveness of population health interventions and population's health literacy. The revised and final CLD contains multiple interacting feedback loops that can be categorized into the four domains: 1) utilization of hospital care; 2) utilization of hospital care; 3) healthcare labor market for hospital care; 4) labor market for non-hospital care; 5) healthcare infrastructure; 6) self-care; and 7) drivers of population health.

As shown in Figure 1, the balancing and reinforcing loops constitute the dynamic hypotheses of how health system components interact and result in a steady level of unmet health needs and rising demands for utilization of hospital care. Also, increasing demands for the workforce in hospital settings leads to decreasing supplies for the workforce in non-hospital settings, medical errors, rising healthcare expenditures, and an undesirable level of population health status over time.

Model Structure

The dynamic hypotheses, as depicted on CLD, formed a basis for our development of SFD and the structure of the system dynamics model. We constructed three modules to represent our insights from the CLD, which include factors and relationships that can lead to mismatches of supplies and demands for the health workforce in Thailand's health systems, including 1) population module; 2) healthcare delivery module; 3) Education and labor market module.

1) Population module

Considering how sufficiency of the health workforce can impact the population health status, we considered each person can occupy a health state by the levels of severity of their illness. The status is reflected in Figure 1 by the stocks: 1) healthy population, 2) population with simple illnesses, and 3) population with complex illnesses. Each health state corresponds to the nature of HRT teams and healthcare models that would be expected to inhibit progression into or regression from more severe health states, as represented by the inflows and outflows. Each person can also progress in terms of aging. Still, we categorized the population to only three groups by ages (0-14, 15-49, 50 and above), also corresponds to the nature of HRT teams and healthcare models usually needed in that age group. The structure of the population is depicted in Figure 1.

2) Healthcare delivery module

In the healthcare delivery module, we displayed the population health demands by health needs as professionally defined (World Health Organization, n.d.). Hence, on the demand side of the healthcare market, each of the health states (healthy population: HP, population with simple illnesses: SP, and population with complex illnesses: CP) creates specific health demands for the health workforce and patient care teams in healthcare models on Figure 2. The accessibility and utilization of each healthcare model on the population model are also described in Table 1.

The supply side of the healthcare market is determined by the capacity of the health workforce in the patient care teams, which can be categorized into nine types of healthcare teams (or nine care models), including 1) ambulatory care, 2) emergency care, and 3) acute care in hospital settings, as well as 4) primary care, 5) intermediate care (a.k.a. subacute care or transitional care), 6) long-term care, 7) palliative care and end-of-life care (a.k.a. hospice care) and 8) oral healthcare usually organized in non-hospital settings. Besides, a workforce who do population health practices such as community-based disease prevention and health promotion are considered within 9) population health teams.

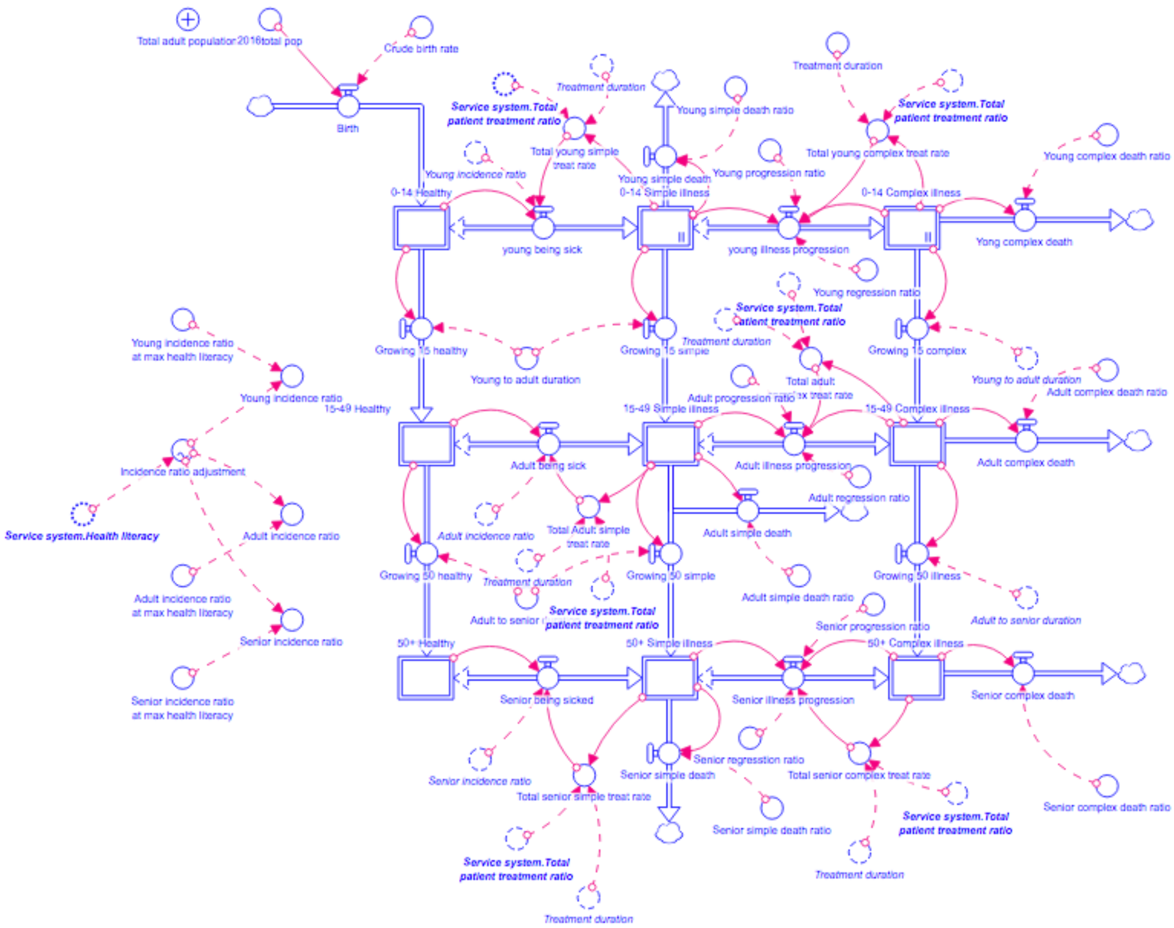

Figure 1 Structure of the population module showing the health states of Thai populations (healthy population, population with simple illnesses, population with complex illnesses) as well as the age of Thai populations (0-14, 15-49, 50 and above)

3) Healthcare education and labor market module

The structure of the health labor market and its relationship with health workforce education and training are shown in Figure 2. The composition of health professions that forms a typical membership of each healthcare model is shown in Figure 3. The supply side of the healthcare market is also the demand side of this healthcare labor market. Hence, the demands for hiring the health workforce in each profession are also determined by the capacity of the health workforce in the patient care teams, which can be categorized into nine types of healthcare teams or healthcare models.

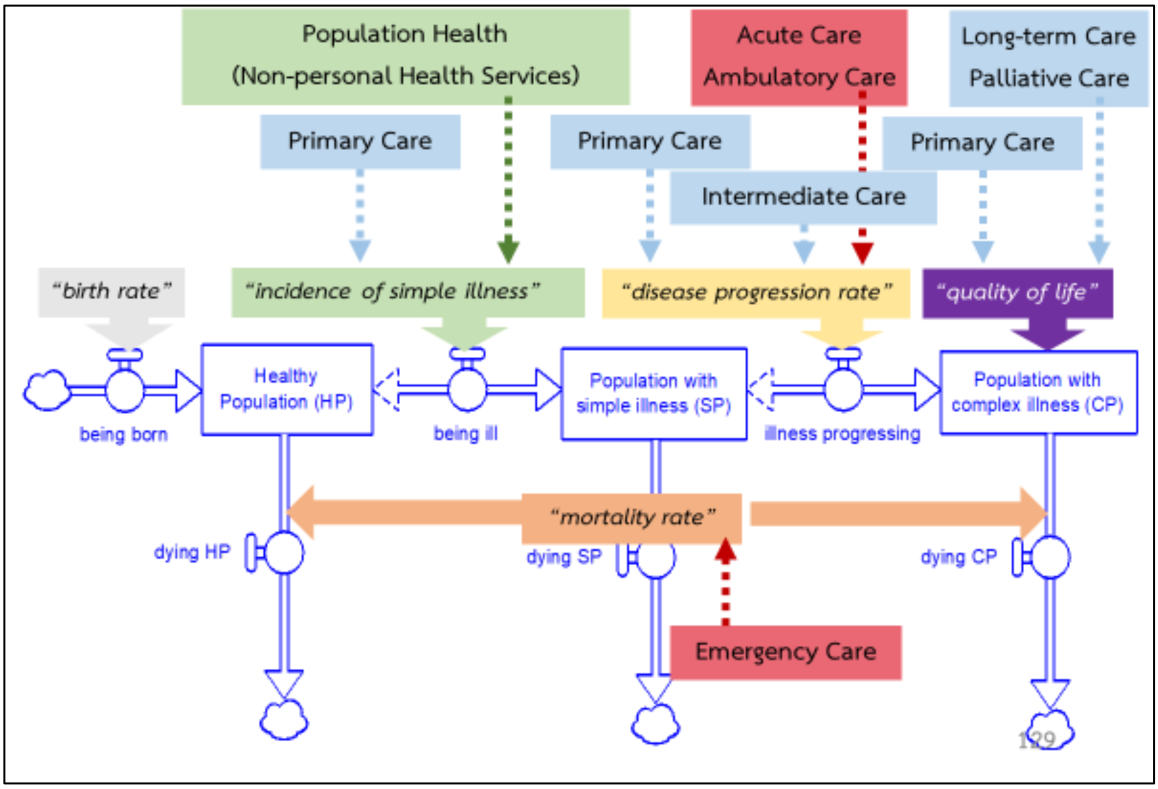

Figure 1 Structure of the health care market and its relationship with the changing population

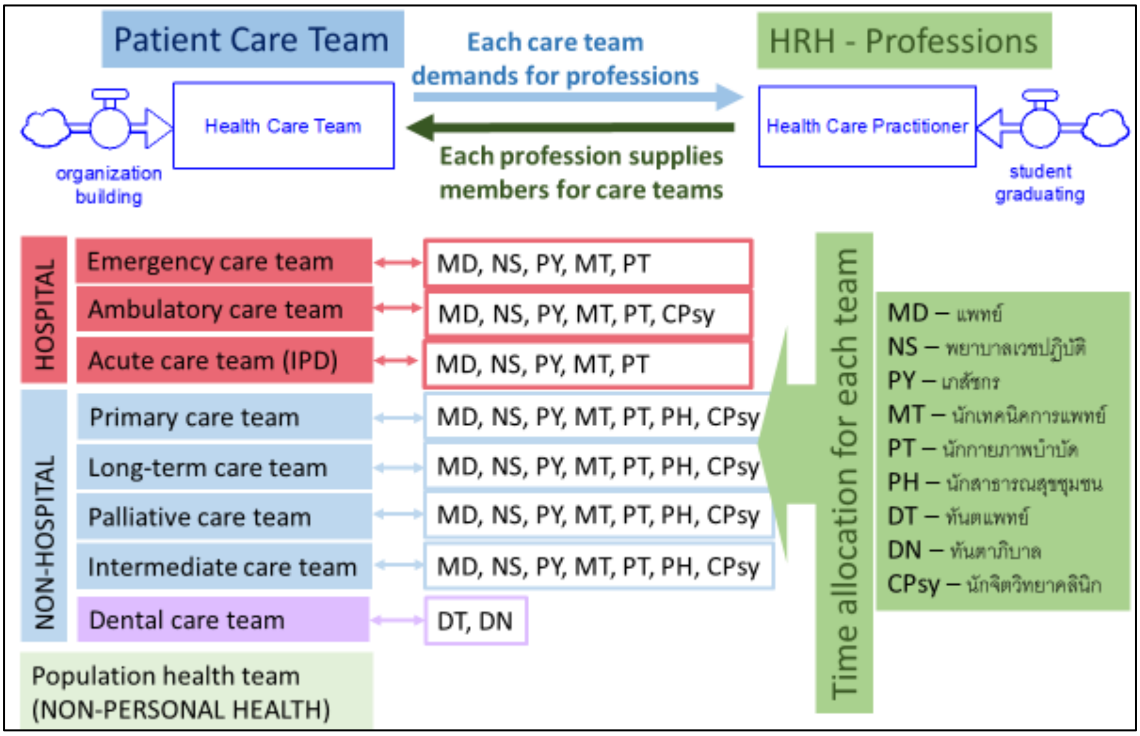

Figure 2 Structure of the health labor market and its relationship with the patient care team in different health care models (MD: Medical doctor, NS: Nurse; PY: Pharmacist; MT: Medical technologist or medical laboratory technologist; PT: Physical therapist or physiotherapist; PH: Public health officer; CPsy: Clinical psychologist; DT: Dentist; DN: Dental nurse)

Table 1 Effectiveness of utilization of each healthcare model on the population model		
Models of Care	**Users**	**Effects**
1. Acute care (IPD)	• Population with complex illnesses of all ages	• Decrease mortality rate • Increase regression from CP to SP
2. Ambulatory care	• Population with complex illnesses of all ages	• Increase regression from CP to SP
3. Emergency care	• All population groups	• Decrease mortality rate
4. Primary care	• A healthy population of all ages • Population with simple illnesses of all ages • Population with complex illnesses of all ages	• Decrease progression from HP to SP • Decrease progression from SP to CP • Increase QOL in CP users
5. Palliative care	• Population with complex illnesses of all ages	• No effects on health status • Positive impacts on quality of life (CP)
6. Long-term care	• Elderly (population with simple illnesses, population with complex illnesses) • Disabilities (young & adult) • Excluding a healthy population of all ages	• No effects on health status • Positive impacts on quality of life (CP)
7. Intermediate care	• Population with complex illnesses of all age	• Increase regression from CP to SP
8. Dental care	• All population groups (oral health)	• Increase regression from SP to HP • Increase regression from CP to SP
9. Population health	• A healthy population of all ages	• Decrease incidence • Via environmental & Behavioral changes

Model Parameters

The parameters used in the model are shown in Table 1. These parameters were used in the initial steady state of our model, which represents a dynamic equilibrium and is numerically sensitive to model parameters.

Table 2 Model Parameter used in the simulation model	
Model Parameter	**Unit**
Population Module	
healthy population	person
population with simple illnesses	person
population with complex illnesses	person
birth ratio	per year
death ratio	per year
progression ratio	per year
curing effect of care	dimensionless
death ratio young complex	death ratio young simple
health-related quality of life (HRQoL)	dimensionless
treatment duration	year
incidence rate	per year
incidence ratio adjustment from access to healthcare	dimensionless
incidence ratio adjustment from health literacy	dimensionless
Healthcare Module	
actual position	person
demand for healthcare	episode/person/year
cost per service	Baht/episode
HRH production cost per head	Baht/person
labor cost per head	Baht/person/per year
the targeted number of public health officers	person
healthcare team	team
practitioner per service	full-time equivalent (FTE)
practitioner leaving job ratio	per year
waiting time before leaving the profession	year
healthcare team expansion ratio	dimensionless
time allocation for administrative (not-patient care) work	team expansion ratio
Healthcare education and labor market module	
the capacity of HRH training program	person/year
batch dropout ratio	person/batch
study period	year
practitioner (practicing HRH)	person
workforce pool (not practicing HRH)	person

To test for policies, we evaluate the policies on four outcomes that concern health workforce planning at the national level. From our GMB process, the sufficiency of the health workforce in Thailand can be seen by 1) population health status, 2) unmet health needs, and 3) health care expenditures.

The first outcome is the overall population health status represented by the percentage of a healthy population in the country, which indicates an adequate health workforce in the effective healthcare models for the demands of population health. Another population health outcome is the health-related quality of life (HRQoL) of the Thai population, which captures the degree and effectiveness of long-term care and palliative care necessary for aging, disabled, and terminal stage patients who cannot be converted to a healthy state. The second outcome is unmet health needs, which reflect limited access to necessary care for their health status. An inadequate health workforce does not only compromise population health status, but can also create long-waiting time, congested patients at healthcare facilities, and equitable access to necessary care. The third outcome is the healthcare expenditure, which is the primary concern of the government and partially address the cost-effectiveness of policy interventions from the societal perspective.

Policy Experimentation

We ran our system dynamics simulations under four scenarios in three main model parameters were changed (i.e., service gap, out-of-pocket cost, and the number of doctors) to conduct policy experimentation and illustrate the potential impacts of each policy in the next 20 years (2017-2038) under the following scenarios:

1) *Scenario I Business-As-Usual (BAU):* All key policy variables were kept constant. Under this scenario, all model inputs, including the effectiveness of the available health workforce actively working in all healthcare models in Thailand, was assumed to be equal and remain unchanged over the simulation time.
2) *Scenario II Decentralizing primary care (Policy#1):* The health workforce planning takes into the account of decentralization of primary care units from the central government (MoPH) to local governments and also limiting new recruitments of physicians into the MOPH facilities from the year 2027 on.
3) *Scenario III expansion of public financing and modernizing primary care (Policy#2):* The health workforce planning takes into the account of expanding the public funding to care delivery by the private sector and also the modernization and digitalization of MoPH primary care units.
4) *Scenario IV Major reforms of care delivery models (Policy#3):* The health workforce planning takes into the account of the significant reforms of all care delivery models by MoPH healthcare facilities. This scenario mainly shifts the focus from only filling the health workforce in hospitals care to produce a significant proportion of the health workforce that is better qualified for working in non-hospital settings.

Model validation

The model is validated using unit consistency test, structural validity test, and behavioral replication test. To test for unit consistency, we used the unit test function in the Stella Architect software. We focused on two dimensions. First, the unit of each variable must have the meaning and consistent with the description of that variable. The second dimension is that the unit must be consistent throughout the model. After testing for the unit consistency, the unit of all variables represents the real meaning of those variables. Besides, Stella software shows no unit error, which indicates that the unit is consistent throughout the model. Therefore, the model passes the unit consistency test.

For the structural validity test, we tested the model by showing the model to the group of experts who works in the healthcare industry, research relating to healthcare service, and the government agencies who manage healthcare security and healthcare services. The experts agree that the structure of the model reflects the actual situation. Therefore, the model passes the structural validity test.

Lastly, we did a behavioral replication test. The reference model was drawn by using multiple data, including the data of the number of Thai populations by ages and their reported health state from the National Statistics Office' Health and Welfare Survey 2007, 2009, 2011, 2013, and 2015. Also, we have the data of oral health state from the oral health survey 2000, 2007, and 2013. The number of the health workforce in Thailand by each type of care model was obtained by the research's primary survey doing December 2017 and January 2018.

The simulation result in the model can trace the actual number of Thai populations receiving care. Therefore, the model passes the behavior replication test.

Results

Our simulation modeling produced results, as shown in Figures 5a, 5b, and 5c, displaying the impacts of the four scenarios on the four primary outcomes. The three policy options were compared to our baseline or the "Business-As-Usual" (BAU) scenario, in which we can observe the consequences of current health workforce policies that most workforce have been working in hospitals.

Under Scenario I (the BAU Scenario), the population health outcomes, both the ratio of a healthy population and health-related quality of life, gradually got worse over the next two decades. Both health systems' performance also declined, as the unmet health needs slowly increased, and health care expenditures kept rising over the whole period.

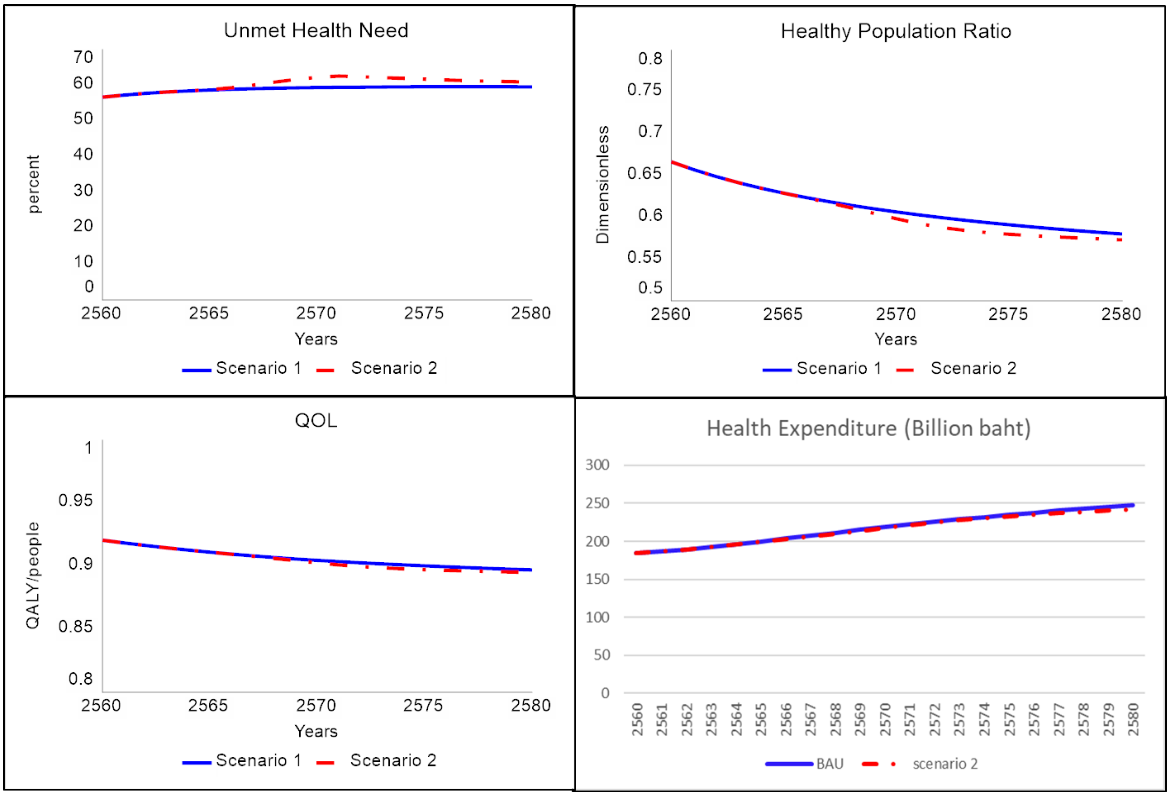

Figure 5a Impacts of Policy#1 "Decentralizing primary care" (Scenario II) on the health systems performance compared to the business-as-usual or the BAU scenario (Scenario I)

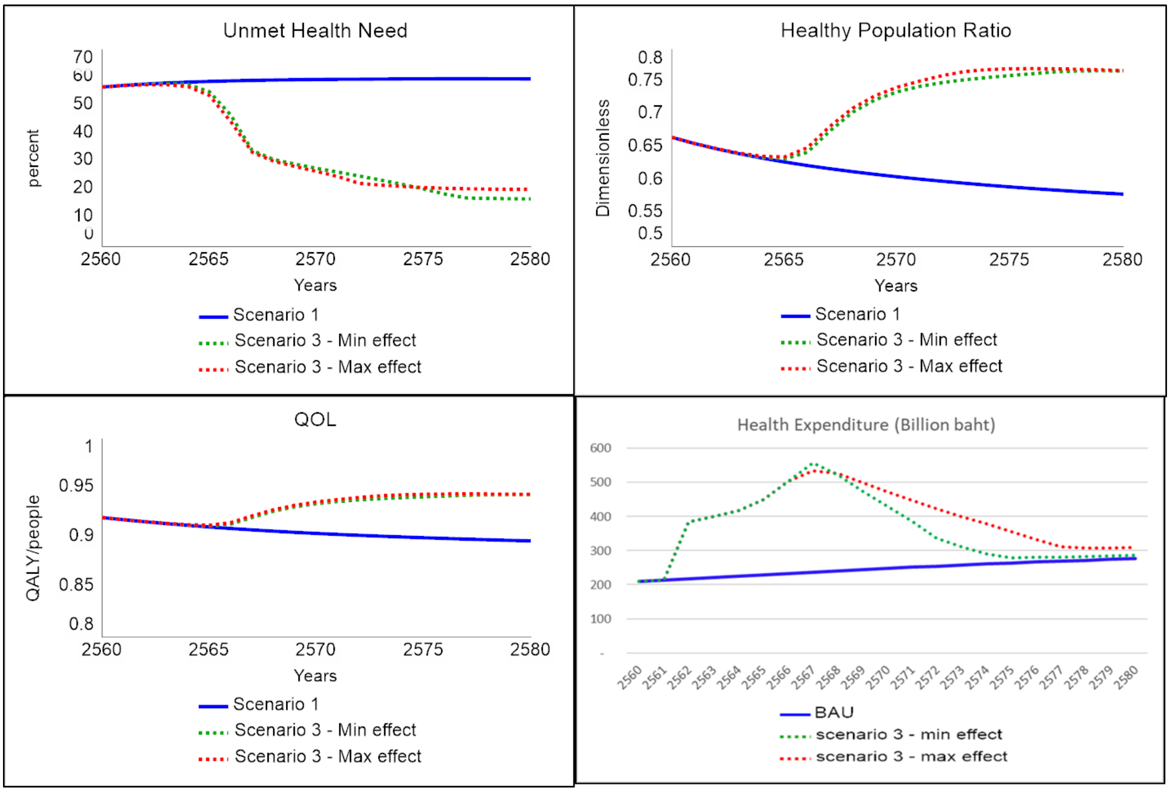

Figure 5b Impacts of Policy#2 "Expansion of public financing and modernizing primary care" (Scenario III) on the health systems performance compared to the BUA scenario (Scenario I)

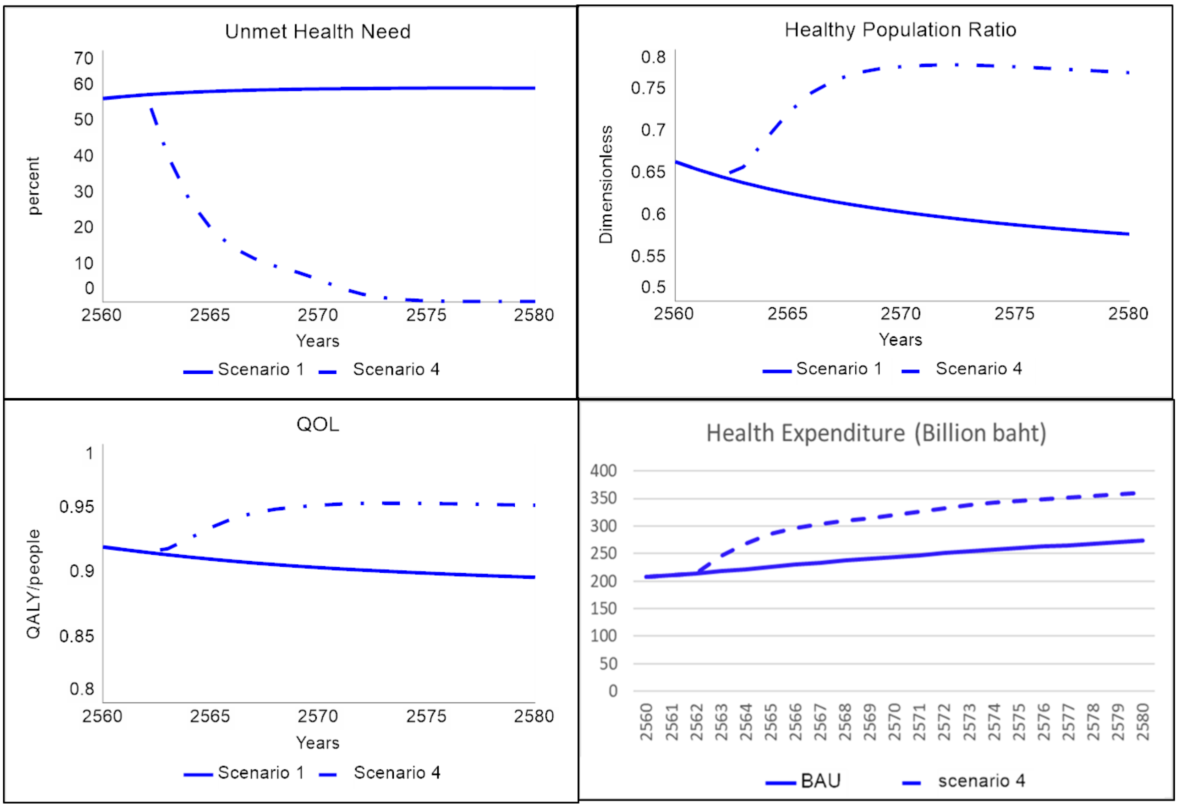

Figure 5c Impacts of the policy III "Major reforms of MOPH care delivery models" (scenario 4) on the health systems performance compared to the business-as-usual or BAU scenario (scenario 1)

Under Scenario II (Policy#1), we considered the impacts of decentralization of primary care units from central government to local governments and limiting new recruitments of physicians into the MOPH facilities from the year 2027 on. These policy options emerged from our GMB process, but our simulation revealed that it produced almost the same patterns of systems behaviors like that of the BAU scenario. The healthy population and unmet health needs of the people got slightly worse than that of the BAU approximately after ten years of this policy implementation, or from the year 2027 (2567 BE) on.

Under Scenario III (Policy#2), we considered the impacts of expanding public financing for private health care delivery while modernizing primary care in the public sector, especially implementing the digitalization of MoPH primary care units. From the year 2022 (2564 BE) or approximately after five years of this policy implementation, the ratio of the healthy population and health-related quality of life rapidly improved. The unmet health also needs shapely dropped around the year 2022 and more gradually dropped furthermore after 2025 (2567 BE). The simulation of total healthcare expenditures displayed an interesting pattern of "worse before better" by immediately and sharply increased after policy implementation but turned to decrease approximately after eight years, or from the year 2025 (2567 BE) on.

Lastly, under Scenario IV (Policy#3), we considered the impacts of significant reforms of all care delivery models by shifting the focus from only filling the health workforce in MoPH hospitals care and producing a substantial proportion of health workforce to promote non-hospital care. The ratio of a healthy population, health-related quality of life, and the unmet health need rapidly improved, similar to the pattern observed under Scenario III. However, we can observe the improvement slightly faster than that of Scenario III. The significant difference was on health care expenditures, which slightly increased from that of the BAU Scenario but not as highly increased as that of Scenario III. However, unlike Scenario III, health care expenditures never went down under Scenario IV.

Discussion and Conclusion

Our study was among the first to investigate plausible scenarios of the strategic HEALTH WORKFORCE planning by taken into the account of healthcare delivery reforms of either Thailand or other low-and middle- income countries (LMICs). The evidence can inform the governance of Thailand's UHC in the next decades to come. By using a GMB process, the policymakers and stakeholders gained a better understanding of causal relationships among factors in Thai healthcare systems related to the sufficiency of the health workforce or the mismatch of supplies and demands of the health workforce. Moreover, and policy options were tested by our quantitative simulation modeling to compare the consequences of each policy.

Initiating significant reforms of all care delivery models, by shifting the focus from only filling health workforce hospitals care to promoting health workforce placements in non-hospital care settings, or creating new care delivery systems for the integration of hospital care and non-hospital, can lead to the most desirable outcomes. The outstanding results can be clearly observed, especially when compared to merely hiring new health workforce in the existing care models as depicted by the business as usual scenario. The healthcare expenditure would increase by approximately 1.3 times of the starting year of 2017. More importantly, the better ratio of health population and the lower level of unmet health needs would result in fewer demands for the health workforce in the long run. The reduced unmet health needs can affect fewer demands for new facilities in both the public and private sectors, too. Overall, this strategic health workforce planning would provide better outcomes in terms of population health status and systems performance. It would be a far superior policy option, especially when compared to implementing a set of new health workforce policies in the exiting healthcare delivery models, as depicted by the scenario I and II.

Alternatively, policymakers can implement new health workforce policies that emphasize on new financing mechanisms for existing healthcare delivery models. The argument would be to increase the efficiency of the health workforce, their healthcare teams, and healthcare organizations. On the downside, as demonstrated by Scenario II, the unmet health needs of people without any access to necessary care would be kept at 20% in the next two decades. Yet, the healthcare expenditure would be approximately 2-fold in the first eight years and then decreased to a similar level of the BAU Scenario. Even with the assumption of using more ICT to receive a greater efficiency of health workforce utilization and care delivery models. While some policymakers believe using more ICT in healthcare delivery can be more efficient than producing and managing the health workforce, our findings suggested the limited effects of ICT without shifting resources among care models or redesign of health care delivery systems. Hence, training a new workforce or retraining the existing ones already working in the health systems would provide a much better outcome.

Beyond the healthcare expenditures, any potential policies that rely on the new workforce, payment mechanism, or ICT systems implemented upon the existing healthcare delivery but not providing an incentive for the reforms of healthcare delivery will minimally affect the health status of the populations. Hence, health workforce policies with a focus on the reforms of healthcare delivery itself, e.g., one that promotes a more balance between hospital care and non-hospital care or a greater integration among care models care, should be preferred. However, these policy options are unlikely successful if only a limited number of healthcare providers in the market offer integrated care. To increase the supplies, the focus of health workforce policies should not limit only public providers and include both public and private providers who qualified. For instance, primary care clinics or rehabilitation centers in the private sector, which is currently not a major focus of CSMBS, SSS, and UCS reimbursement systems, can team up with public or private hospitals to establish an integrated care process for their patients. However, by this option, healthcare expenditures can increase more rapidly in the early years due to the higher unit cost of health care services in the private sector compared to that of public providers.

As put forth by (Milstein, Homer, & Hirsch, 2010), system dynamics modeling can demonstrate the consequences of policy options of healthcare reforms in a more comprehensive way. However, our study may have some limitations in predicting future outcomes if the assumptions used to construct our system dynamics modeling is too far from the complex reality. The health outcomes can be altered from the simulated ones for several reasons, including 1) the quantity and quality of health workforce in the future might be inadequate for all health demands of Thai populations, 2) the patients have a preference for specific types of healthcare teams, or 3) their accessibility to new care models was not as high as expected. Moreover, the healthcare expenditures may increase even more than the simulated numbers if the government expands the UHC benefit packages from the existing ones. Lastly, due to the exploratory nature of our study, our model reveals the trend of population health status and systems performance outcomes as the consequences of each policy option. Still, we did not aim to precisely forecast an exact amount of healthcare expenditures or any other results. More specifically, for simulated healthcare expenditures, we did not take into account of the inflation in our model yet.

Nonetheless, building upon the present study, policymakers of healthcare reforms can benefit from further analyses. The synthesis of additional policy options by group model building and testing such policies by simulation modeling can help not only the strategic planning health workforce at the national level but also the planning and evaluation of the ongoing UHC reforms. Our modeling process also informs policymakers and stakeholders about what data in health information systems is crucial to the strengthening of UHC governance, particularly regarding managing the health workforce and health systems performance. Hence, this iterative nature of data collection and data analysis could be a lesson learned for the UHC policy process, not only in Thailand but also in other LMICs as well.

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