A System Dynamics Study on Uneven Distribution of Doctors in Nepal: Rural Vs. Urban

By

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Abstract

Nepal has been facing issues of the geographical maldistribution of physicians since past years. The various documentation has been about the reason for brain drain to abroad but, only little is known about the salient factors that influence the choice of location either rural or urban setting for those doctors who do not migrate. In recent years, the production of medical doctors within Nepal is increasing trend with growing medical colleges, but their distribution in rural locations is not adequate. There is a huge discrepancy to the doctors to population in rural versus urban area. So, the purpose of this study was to analyse the major factors that influence the choice of urban or rural location for the future clinical practice of Nepalese doctors and to identify the appropriate policy to address the problem and try to solve it to some extent. To study the problem, the system dynamics modelling approach was used in order to analyse the distribution trend of doctors in rural versus urban location and to replicate the problematic behavioural trend.

The model reveals the feedback mechanism of the most influential factors for doctors' resistance not to go and practice in rural setting. The effects of learning opportunities from their experienced seniors, effects of the additional income from the dual practice and effects of work stress and job satisfaction on the migration from rural to urban drives the entire distribution of doctors in the model. The model managed to replicate the problematic behavior. The wishful thinking rather than the actual policy is developed o in order to relieve the problem.

This thesis consists mainly six sections with relevant subheading. The introduction part deals with the background about the problem and problematic behavior of doctors to population in urban and rural setting due to the uneven distribution of doctors in those location of Nepal while the relevant literatures and studies relating to the pull and push factors for internal migration is in the literature review section together with the introduction to the system dynamics methodology used. The next section validates the structure and behavior produced by simulation to build confidence in the model. The model behavior section deal the simulation results with explanation to how the structure causes behavior. The policy "wishful

Thinking" is proposed, and the policy structure is developed and behavior is analysed to address the problematic behaviour is described in the policy section. The concluding remark with a limitation and scope for further study is presented in the conclusion section.

List of Acronyms

CBS: Central Bureau of Statistics

GDP: Gross Domestic Product

HRH: Human Resource for Health

MBBS: Bachelor of Medicine and Bachelor of Surgery

MOE: Ministry of Education

MOHP: Ministry of Health and Population

MOF: Ministry of Finance

PSC: Public Service Commission

SD: System Dynamics

UN: United Nations

WHO: World Health Organization

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Chapter 1: Introduction

1.1 Background

Human Resources for Health (HRH) are an important factor for the development of health care system of any nation. But the ongoing global trend of migration of the health care worker, especially the doctors, from medically less served to better served areas has created the unbalanced distribution of health personnel between and within countries. The uneven distribution exists due to both internal migration (usually from a rural to an urban setting) and external migration (from developing to developed countries).This severe geographic imbalances in the availability of health workers has been a longstanding and serious issues worldwide affecting countries at all levels of income, whether its developing countries like Nepal or developed countries. Figure 1. exhibits the mismatch of physicians to population health in different geographic regions considered as the most commonly named current human resource policy concern in the health sector across OECD countries (Ono et al., 2014)

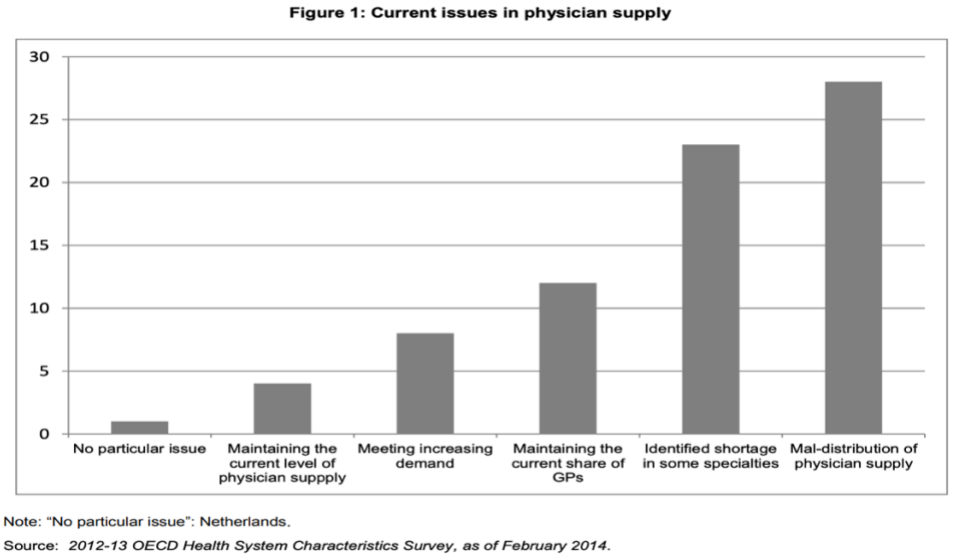

Figure 1. Current issue in physician supply

(Adapted from: Ono, Schoenstein, & Buchan, 2014)

Nepal is no exception. Nepal is among the world's poorest countries with a population of approximately 29 million with 82% of the population living in rural areas and 25.2% living below the national poverty line (Central Bureau of Statistics, 2012). Nepal is

administratively divided into seven provinces with each province having rural municipalities (called Gaunpalika) and urban municipalities (called Nagarpalika) (Ministry of Health and Population (MoHP), 2010). The country spends 5.3% of its gross domestic product (GDP) on health. In terms of medical facility allocation, Nepalese have 0.08 health centres per 100,000 population and 2 Doctors of Modern Medicine per 10,000 population (P Ravi Shankar, 2010).

In last two decades, Nepal is considered to have made remarkable progress in health sector. Nepalese's life expectancy at birth has increased to 70.77 years in 2017 compared to 50 years in 1981. Similarly, between 2000 and 2016, neo-natal mortality fell from 39 to 21 deaths per 1,000 live births, infant mortality rate declined from 64 to 32 deaths per 1,000 live births and under-five mortality decreased from 91 to 39 deaths per 1,000 live births. Likewise, the maternal mortality ratio decreased from 548 per 100,000 live births in 2000 to 239 in 2016 (Table 1). Despite these achievements, substantial inequities in health outcomes across different geographic regions and socioeconomic groups persist (Ministry of Finance, 2012).

Indicator	Year			
	2001	2006	2011	2015/2016
Total fertility rate	4.1	3.1	2.6	2.3
Infant mortality rate (per 1000 live births)	64	48	46	32
Urban-five mortality rate(per 100 live births)	91	48	46	39
Antenatal care (by skilled provider percentage)	28	44	58	84
Deliver care (by skilled provider percentage)	11	29	36	58
Maternal mortality rate (maternal deaths per 100,000blive births)	548	425	328	239
Stunting rate(percentage of children under 5 age) years)	57	49	41	36
Wasting rate (percentage of children under 5 age)	11	13	11	19
Underweight rate percentage of children under age 5 years)	43	39	29	27

Table 1. Indicators of major health outcomes in Nepal

Source: Tamang, Poudel, Karki, & Gautam (2020).

As stated by Nepal Medical Council, there are approximately 20 medical colleges that produces annually 1,500 to 2,000 medical graduates. According to the report of Ministry

of Finance[1], the number of registered medical graduates have increased considerably from 3,928 to 21,033 from fiscal year 2001/2002 to 2018/2019, as shown in Figure 2.

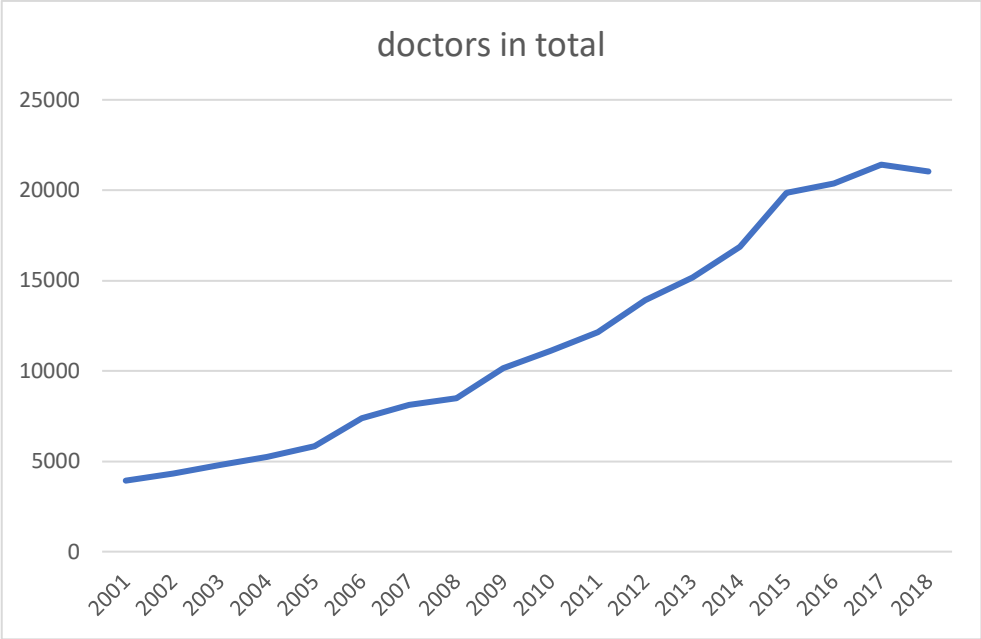

Figure 2. Total registered doctors in Nepal (Source: MOF 2018/2019)

Although Nepal exhibits a considerable increase in number of doctors every year, the ratio of physicians per 10,000 people in Nepal is far below the standard of 23 health service providers per 10,000 people set by World Health Organization (World Health Organization, 2006). Despite these improvements and increasing health workers, especially doctors, Nepal faces a shortage of doctors and an most importantly uneven distribution of doctors between andbetween rural and urban areas of the country. One of the reason for the shortage of doctors, in general, in Nepal can be associated with 'brain drain' of qualified medical doctors, with more than 500 doctors emigrating each year, making it difficult for the country to maintain even supply of doctors (Ministry of Health and Population, 2017a).

The report of Ministry of Health and Population (2012), states that there are sufficient number of doctors in Nepal and is expected to rise. But the main problem lies on the fact that most of these doctors are based in urban areas and not serving the rural

1 https://www.mof.gov.np/en/archive-documents/economic-survey-21.html

communities that need them most. More often it is said that oversupply of doctors did not result in equal distribution between urban and rural areas.

Another primary factor for the shortage of health workers is the increasing number of health personnel seeking employment abroad. Historically, doctors' brain drain in Nepal is found to begin several years ago (World Health Organization, 2006). However, presumably the doctors' brain drain in Nepal has intensified in recent years, especially due to 'external brain drain'. The Ministry of Health and Population (2017), report that an estimated 16 percent of registered Nepali doctors were outside the country, either studying or working. Moreover, doctors staying in Nepal are more likely to practice in urban area which has been a challenge in deployment and retention of all the health workers in rural Nepal. A survey of career intentions of medical students in Nepal showed that 88% of medical students were likely to practice in urban centers (Huntington et al., 2012).

Since, it is noted that the absence of doctors and qualified health professionals in the most remote areas has also been a longstanding issue. These issues are stimulated by the movement of high-level health workers, such as doctors, to urban areas or abroad, mainly due to better career opportunities, financial incentives, working environment, better employment prospects for health professionals and their spouse, easier access to private practice, better infrastructure, and more social amenities than rural areas.(Ministry of Health and Population, 2017a).

There have been tremendous efforts by Nepal's Ministry of Education (MOE) to address the issue of low physician density in rural Nepal. A scheme of 10% scholarship are provided to the student in private medical schools owned by a Nepali citizen and medical schools in Nepal, owned by non-citizens, must reserve 20% of seats each session for free education of students. This scholarship binds students to serve 2 years in rural part after graduation. However, the impact of such program have been effective, in the short-term, to place into rural areas but after their mandatory rural service completion they go to abroad for better opportunities (Ministry of Health and Population, 2017b)

An article by (Huntington et al., 2012)) states that the tuition fees of private medical colleges are relatively expensive, three private medical schools averaged about US$31,000 for the 5.5 years of training, which is about 30 times the average annual per

capita income of GDP in Nepal. By contrast, the government subsidized tuition fees at the IOM are only about US$2400 for the same 5.5-year program. Thus, the new graduates of health workers are distributed in private hospitals in urban areas and publicly run government hospital in remote areas. Though expansion of new graduates is possible from these kind of scholarship schemes but due to the limited number of residency positions in Nepal preferred specialty, these health workers seek to go abroad for further training and study after completion of their obliged practice in rural or urban area. The other various financial incentive like remote allowance packages were also introduced for accepting the job in a rural and remote area in order to retain the doctors (Tamang et al., 2020). Apart from these initiatives, there were no programs to address the retention of health workers within the country.

Shankar (2010) mentioned in his findings that the health workers' migration from Nepal is a major problem that leaves the country with maldistribution of health workers. There are various factors behind the shortage and disparity in the distribution of doctors between urban to rural which have not yet been studied in a systematically. Thus, this study aims to identify influence of different financial and non-financial factors that causes the disparity in urban and rural distribution doctors using system dynamic approach.

1.2 Problem statement

Nepal has a remarkable progress in health sector with production of sufficient health workers (Ministry of Health and Population, 2012). Despite an of HRH production, the "brain drain" of health workers has been identified as a major concern in Nepal (Dussault & Franceschini, 2006). These shortages have led Nepal to experiences uneven distribution of health workers leading to critical shortage of health workers in most rural part of the country with highly concentration on urban cities like Kathmandu, Pokhara and Chitwan. This leaves the health worker-to-population ratio at 0.67 doctors and nurses per 1,000 individuals, which is significantly lower than the World Health Organization's recommendation of 2.3 doctors, nurses and midwives per 1,000 individuals (Ministry of Health and Population, 2017a). Based on above context, the uneven distribution of health workers in Nepal is problematic in nature which the present study attempts to understand using the SD approach.

There has been large numbers of internal migration studies including high income countries or developing countries like Nepal which are more theoretical and descriptive in nature (Huntington et al., 2012), (Hayes & Shakya, 2013), (Ailuogwemhe et al., 2005) (Dussault & Franceschini, 2006), and so on which has contributed to update the knowledge about underlying causes of internal migration by providing the trends or statistical data. However, there are only few studies that developed the model using system dynamics based on those theories which only explains the causal relationships between key variables. Most empirical studies use data and statistical analyses to measure the impact of internal migration on health outcomes. The majority of these research's findings are merely descriptive in nature and lack a solid foundation for policy analysis and design. Therefore, this research tries to explore the patterns of the uneven distribution of doctors' in urban and rural areas of Nepal, the causes of such flow, some consequences and introduce the various policies options to address the problem of shortages of doctors to the policymakers.

1.3 Research Objectives and Questions

The research objective and questions have been formulated based on the above-mentioned problem description. The main aim of this thesis is to enhance the better understanding of the underlying structure that influences and governs Nepalese medical doctor's internal migration dynamics. The study has tried to represent the current structure of the Nepalese medical doctors using the system dynamic models with connection to different causes of internal migration. Moreover, this study aims to examine the major determinants of the geographical imbalances of the medical doctors i.e. push and pull factors that drive the patterns of internal migration. The study also attempts provide policy suggestion to address government policy by identifying, exploring and explaining different factors that influence the migration decisions.

Therefore, the specific objective is stated below;

- To explore the dynamics for uneven distribution of medical graduates among urban and rural part of Nepal.

Based on the objective, a system dynamics model will be developed, and the simulated behaviour will be analysed to test policy intervention point.

The following are the research questions formulated:

- What are the key factors that impact the inequitable geographical distribution of medical doctors and how these factors might be addressed to improve retention rates?
- What are the factors influencing a medical doctors' decision to relocate, stay or leave a post in rural or remote areas and move to urban areas of Nepal?

1.4 Research Methodology

In order to fulfill the research objective a quantitative system dynamic modeling and simulation-based analysis approach is adopted. This modelling approach allows us to represent and understand relevant interactions between different causes and their effects. In that way, it is possible to facilitate a variety of formal analyses that enhance our understanding of interaction between factors that affect internal migration of doctors. Thus, a System dynamics approach has been used as the methodological tool to understands the stated research problem. SD has been developed specifically to facilitate the analysis of the relationship between the structure and behavior in such complex feedback systems (Sterman, 2000). SD allows studying the relationship that exists between structure and behavior in complex and dynamic systems, so as to understand the structural origin of a problematic dynamic development and to identify policies for the purpose of modifying that development (Sterman, 2000).

And for research strategy mixed method approach has been used where both qualitative and quantitative data has been deployed. For the purpose of the study, secondary data has been used mostly with limited insights from working doctors as qualitative inputs. The major sources of secondary data are from publication by various health administration bodies in Nepal.

1.5 Reference Mode

In order to address the first research question, the reference mode is necessary to show the historical trends on the number of medical doctors in Nepal. The recent data shows that there is an increasing trend of medical doctors' production with rapid medical school expansion, and the population is also increasing but as per the estimation of (Butterworth

et al., 2008) the physician ratio is 2.4 physicians per 100,000 people about 100 times lower than the minimum acceptable ratio stated by WHO (World Health Organization, 2006). Despite an improvement in the ratio from 1.61 to 7.5 per 10,000 population is observed in Figure 3., it cannot be considered an equitable distribution due to discrepancy in the medical doctors' density in rural vs urban areas of Nepal as shown in the Figure 4. Therefore, the doctors to population ratio are computed by total number of medical doctors registered divided by total number of populations.

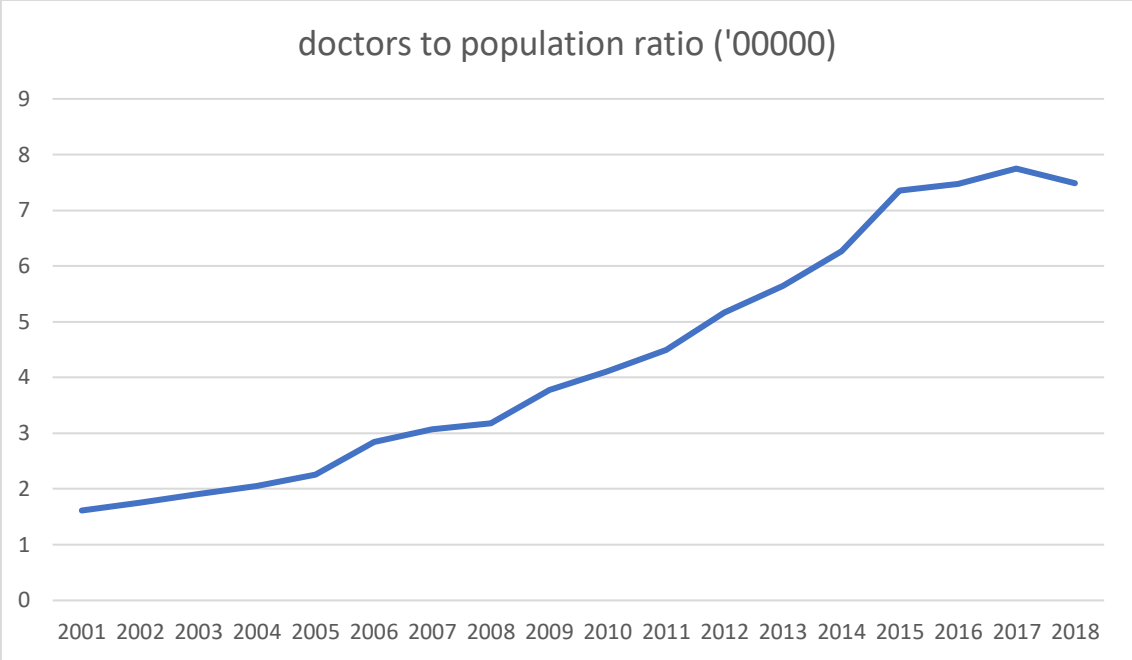

Figure 3. Doctors to Population ratio ("00000)

Data source: MOF (2001-2018) & United Nations - World Population Prospects

https://population.un.org/wup/Country-Profiles/

The report from UN[2] states that, the population in rural areas decreased from 86.6 percent (2001) to 80.26 percent (2018). In comparison, between 2001 and 2018, the number of physicians in rural areas increased from 1,571 to 8,413 indicating an improvement in the situation. Nonetheless, when the ratio between urban to rural are compared, we see that there is a huge , the doctor-population density in Kathmandu (urban) is estimated to be

2 *https://population.un.org/wup/Country-Profiles/*

about 40 times that in rural Nepal (Pathiyil Ravi Shankar, 2017) despite being an improvement, cannot be considered an even distribution of medical doctors.

This ratio is calculated as total number of rural doctors divided by the number of the rural population commonly referred to as the rural doctors to rural population ratio. Similarly, for urban doctors to urban population ratio, it is calculated as total number of urban doctors divided by the number of the urban population. The reference mode for the study is based on data available on the Ministry of Finance (MOF)[3] Nepal as shown in below Figure 4.

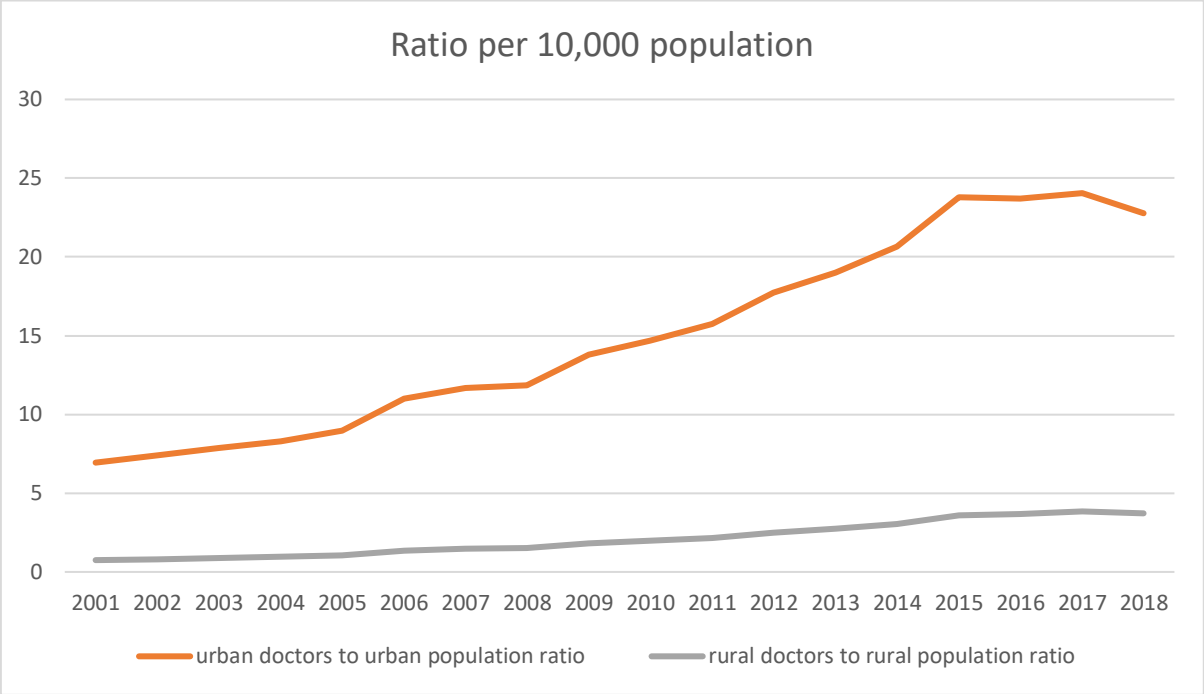

Figure 4. Urban doctors to urban population and Rural doctors to rural population ratio (00,000)

Data source: Ministry of Finance (2001-2019)

[3] https://www.mof.gov.np/en/archive-documents/economic-survey-21.html

Chapter 2: Literature Overview and Methodology

2.1 Literature Review

The international and internal mobility of health workers is not a recent trend. In their study Araújo & Maeda (2013) identified that, throughout the world, there is a tendency for the health workforce to be concentrated in well off urban areas rather than in rural and poorer areas. It was noted that excessive migration of doctors from rural areas to urban pocket has intensified the severe imbalances in the distribution of health care workers across and within countries.

In Bangladesh, 35 percent of the doctors and 30 percent of the nurses practicing in the public sector are in metropolitan areas which contain only 15 percent of the country's population (Dussault & Franceschini, 2006). In Sudan, the doctor to population ratio in urban settings is 24 times higher than in rural locations, the same indicator for nurses is 20 times higher in urban locations (Lemiere et al., 2011). In the same way, the Kathmandu valley has one doctor for 850 people but in rural areas the number is one doctor for every 150,000 people[4]. The doctor-population density in Kathmandu is estimated to be about 40 times that in rural Nepal (Ailuogwemhe et al., 2005). Thus, the problem of rural recruitment and retention of health workers is a world-wide issue affecting countries at all levels of income. These inequitable distribution of medical doctors or health workers can contribute to great disparities in health outcomes between rural and urban population.

The pattern of migration of health workers relevant in Nepal is shown in the Figure 5. This explains the patterns of movement for medical doctors too. The medical doctors are likely to move from rural areas to either urban public sector or urban private sector or secondary and tertiary level public sector. Whereas from these different sectors, the movement of medical doctors are extended to the rich country health sector.

[4] Patan Academy of Health Sciences. Nepal at a glance. [Cited November 18, 2017]. Available from: http://www.pahs.edu.np/about/about-nepal/

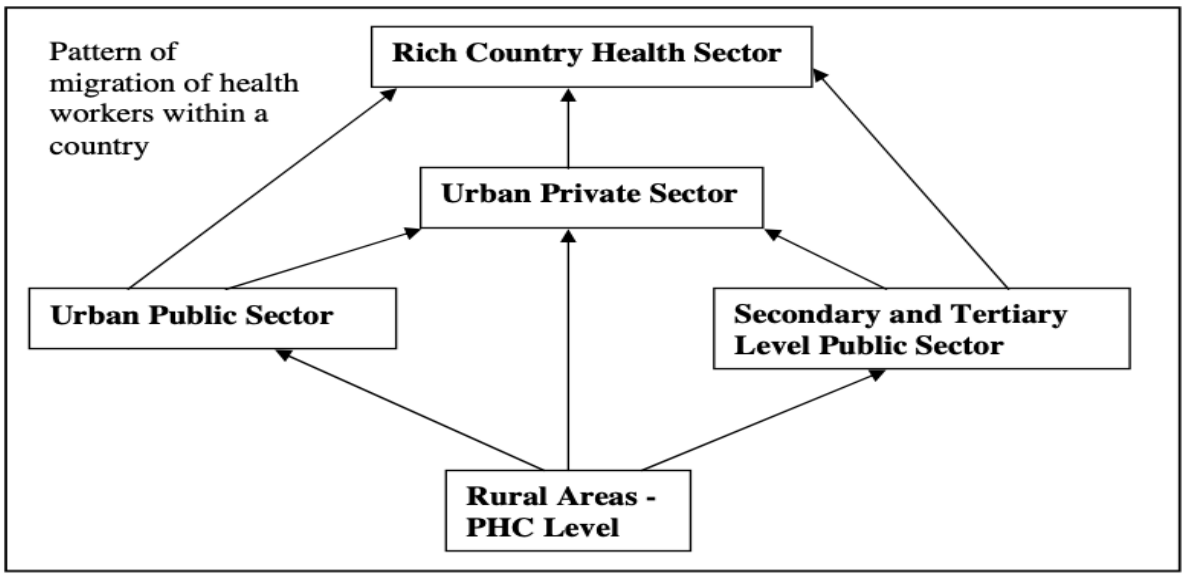

Figure 5.Schematic of the factors affecting the migration and movement of health workers.

Source: Adapted from study of(Ailuogwemhe et al., 2005)

(Zurn et al., 2002) identified that the urban areas are more attractive due to the opportunities they offer in terms of career development and educational advancement, better employment opportunities, easier access to private practice (an important factor in countries where public salaries are low) and lifestyle related services and amenities, and better access to education opportunities for their children. With this there are some cases of over staffing in urban areas; whereas in rural areas there are understaffing of medical doctors. Paradoxically, instead of encouraging movement of staff towards rural areas, excess number of health professionals in urban areas often promote external "brain drain" (Dussault & Franceschini, 2006). It is too be noted in Nepal, there are large numbers of vacant posts (47.3%) for medical officers in all districts. Staff vacancies and absenteeism are common with only 85% of sanctioned posts filled and only 70% are present, others presence is questionable (Ministry of Health and Population, 2012).

There are different factors for different health care workers categories. The high skilled workers like medical doctors are reluctant to work in urban and wealthier places possibly because of the high cost of education and hence desire to earn the higher income. As noted in research paper (Huntington et al., 2012) "Neo-classical economics theory underscores this idea by explaining that migration patterns are caused by differences in

wage rates between locations, suggesting that migration is mainly an individual decision taken to maximize income". The barriers factors in rural practice include career development incentives, rewards or recognition, mentoring and supervision, salary and remuneration that influences the choice of practice location (Brooks et al., 2002). In Nepal, a qualitative study of rural generalist physicians identified many of these same factors (Butterworth et al., 2008). There are other multiple push and pull actors influencing a medical doctor for the choice of selection of practice area.

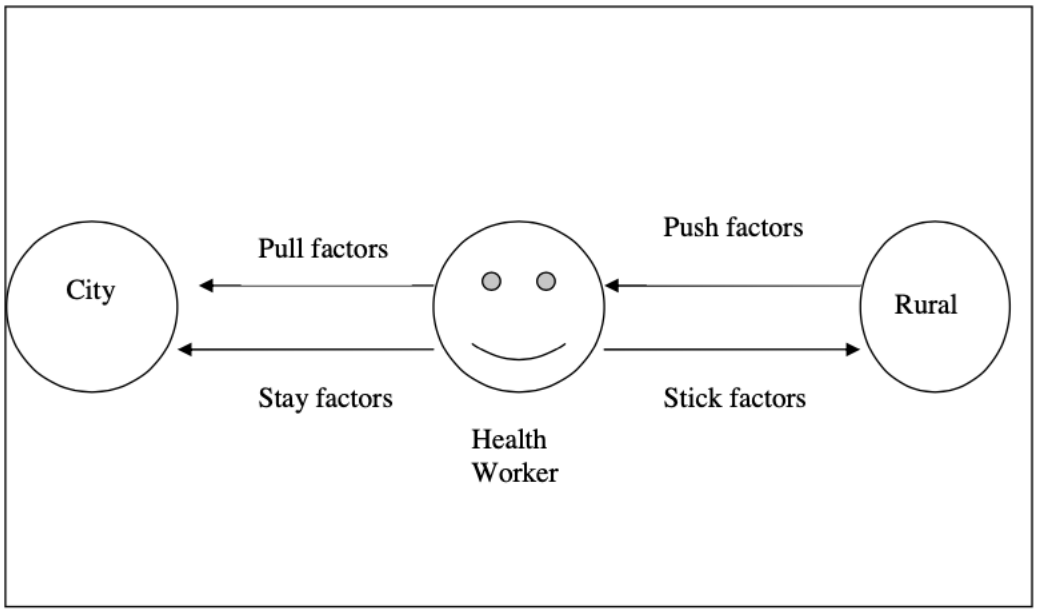

Figure 6. Schematic of the factors affecting migration

Source: Adapted from study of (Ailuogwemhe et al., 2005).

The "pull" factors are those that attract health professionals for a given post/location (higher income or possibility of practicing in the private sector, improved working and living conditions, and etc.). The "push" factors are those that may coercively influence the health workers not to take up a post in a remote location and not to remain there (Lehmann et al., 2008). Araújo & Maeda (2013) explained in their paper that the pull factors associated with migration include higher salaries, better working and living conditions, more opportunities for continuing education and career development. The push factors may include limited job opportunities (both financial and professional) in the home country, as well as political and social instability.

Based on the various empirical evidences the following are the listed factors that have varying degree of influences on the employment of decision of medical doctors which are briefly explained below:

1. Learning Opportunities

The study in Ghana demonstrates that lack of career development and mentoring by specialists and senior doctors was the most critical disincentive for doctors to work in remote or rural postings. The absence of senior posts in rural areas, lack of recognition from managers and slower career progression are other factors associated with the feeling of "professional imprisonment" identified by those working in rural and remote posts in Ghana. The same study in Ghana shows the evidence in rural periphery lacks access to continuing education (professional courses and workshops) is limited to those not working in the urban areas. (Snow et al., 2011).

(Butterworth et al., 2008) identified career and promotion prospects along with continuing medical education as some factors that affected the recruitment and retention of medical doctors in rural areas. They stated that rural facilities lack internet access to attend various conferences that helps them to build their career. Most of the young doctors felt professional isolation and lack of cooperation by other permanent government health workers including senior doctors who treated them poorly that affects the motivation to deployed from rural practice.

2. Income and Salary

Salary and renumeration significantly influences the decision to work. Since, the urban places offer the opportunities for dual practice i.e. private practice to supplement their income and increase job satisfaction, which are less available in rural areas, thus there are high chances that medical doctors are motivated to practice in metropolitan areas. It is evident from the study in Bangladesh that if non-private-practice allowance are given to medical doctors, there are high chances that the young medical doctors job preferences will be in rural areas. A study in Nepal by (Huntington et al., 2012) provided an evidence that medical students who came from families with higher incomes have greater likelihood of practicing abroad because of good salary which is considered as a very important to their decision to become a physician, and which is less likely to earn a good

salary in Nepal. In the same study of medical students in our country, two thirds agreed to the statement that 'Additional payments from the government would make me more likely to practice in a rural area'.

Another study by (P Ravi Shankar, 2010) also found that high tuition fees in private medical schools and low Government wages prevent recent graduates from taking up rural positions. As per (Tamang et al., 2020) the other motivation factors to stay in rural areas were rural allowances, opportunities for training and preparation time for the postgraduate exam. Study by (Hayes & Shakya, 2013) identified good salary ("much more than in Kathmandu") as important factor to attract the medical doctors to work in rural areas. (Thapa et al., 2014) (Rockers et al., 2011) and (Miranda et al., 2012) also suggested that doubling of the salary and incentives would make rural postings more attractive.

3. Work Pressure and Job Satisfaction

The physicians experiences a lot work stress in terms of long work hours , low supply of doctors, overcrowding with patients, lack of proper sleep due to night shifts , many patients to be treated and relatively low in comparison to the standard income per patients treated and other factors like confrontation with illness and death on a daily basis and so on. These work pressure has been found to affect job satisfaction and in turn increases turnover intensity. (Khan et al., 2003) also explained that work pressure leads toward leaving the job. Due to too much of work, doctors feel dissatisfaction, dissatisfied physicians are more likely to leave the job (Khan et al., 2003). The study of (Yu et al., 2015) revealed work stress as negatively correlated to job satisfaction and had a positive effect on turnover intention.

2.2 System dynamics approach as Methodology

As per Sterman (2000), system dynamics has been developed specifically to facilitate the analysis of the relationship between the structure and behavior in such complex feedback systems under uncertainty. The behavior of any system or entity is principally caused by its structure. The model validation is done in order to evaluate and test the different theoretical hypotheses about how the model structure produces its behavior by comparing model simulation outcome to historical data.

This research aims to construct an SD integrative model that captures the dynamics of Nepalese Medical doctors' internal migration. The model will give insights on the major feedback loops the underlying causes for such behaviour of Nepalese medical doctors. The model is the demonstration of hypotheses we have developed that explains about reason on what happened and why, based on different relevant migration theories. Moreover, the upon analysis of the model structure and behaviour, the various policy options, its feasibility, policy costs, implementation challenges, and best policy fit are designed that aims to solve the problem of geographical imbalances on distribution of medical doctors.

Since system dynamics models use people‟s mental models (mental representations of reality) as a source of data along with written data and numerical data, the present research engaged both qualitative and quantitative research strategies. The numerical data was obtained by secondary data collection methods, i.e. from statistical reports and other government publications. Among the primary sources of data were brief talk with people from medical background on the influential factors for migration or relocation of practice location.

The system dynamics method has been applied to issues of population health since the 1970s. (Homer & Hirsch, 2006), (Hassan & Minato, 2017) has applied system dynamics in Malaysian Healthcare resources and explained that the application of the system dynamics model provides a framework for understanding the feedback structure and the complex system of the components in healthcare resources. Various studies have adopted system dynamics methodology on healthcare issues over the years, mostly covering countries in developed regions and has been claimed as a useful tool in health care research like Malaysian health care resources (Hassan & Minato, 2017), Forecasting the absolute and relative shortage of physicians in Japan (Ishikawa et al., 2013) and Transformation of potential medical demand in China: A system dynamics simulation model (Yu et al., 2015) and so on. Similarly, this work is also based on System dynamic modelling approach, a methodology and computer simulation modeling technique for framing, under- standing and discussing complex issues and problems. In the current study, Stella software will be used to implement the SD simulation model.

Chapter 3: Model Description and Simulation

3.1 Model Overview

This chapter describes the simulation models´ structure and explains how the different literature theories applied are used in the model. In addition to these, it also describes the dynamics generated in the model during the simulation time frame. The three different sectors of the model in terms of stocks flows and how majors structure formulations are developed has been explained in detail and the interactions between them. The following are the model's different sectors that were developed which generated the dynamics in the system:

- Medical student sector
- General Doctor framework sector
- Vacancy for rural positions
- Learning effect
- Additional salary and income effect
- Work pressure and Job satisfaction effect
- Population sector

After this, causal loop diagram has been constructed for defining framework in less detailed perspective explaining the major feedback loops and their interactions. The documentation of the model that explains the values and their sources can be found in Appendix A. After that the relevant policy has been introduced in the model to solve the problem stated. Furthermore, the relevant policy choice has been explained in Chapter 6.

The time horizon for the explanatory model simulation is from 2001 till 2018. As stated by Generally, the modeller should back trace the data from historical trend in order to develop the reference mode of behaviour. A time frame of 20 years is added to analyse the effects of policy on the model behaviour. In order to evaluate the policy model runs from 2001 to 2080 with policy.

3. 2 Model Assumptions

This section provides the explanation to the overall set of assumptions made throughout the modelling process. It defines the scope and boundary of the model. The following points highlights the basic assumptions made in the model:

3.2.1 Assumption 1: system boundaries

The important exogeneous variable in this modelling process is:

- FRACTIONAL INCREASE IN MEDICAL COLLEGE SEATS CAPACITY Ministry of Education (MOE) of Nepal determined the number of medical students recruited each year from secondary schools. With the gradual increase in the number of medical colleges further capacity expansion was planned and therefore the model was parameterised with an average rate of percent on medical seats capacity for medical students per year, a number which applies across the model's 18-year time horizon.
- RESERVATION QUOTA SEATSs also assumed as exogenous. Every year the medical colleges provide the reservation quota seats (as mentioned in Scholarship rules 2060), as self-paying seats or scholarship seats for students. Further, the scholarship seats are divided into merit scholarship quota with fraction of scholarship reserved for special provision and out of total scholarship seats, the remaining seats are for merit scholarship quota. These scholarship seats are an attempt of government to address the issues of lack of doctors in rural area and prevent the doctors from emigrating through the compulsory bonding service program. These reservation quotas are allocated for disadvantaged socioeconomic group like remote background students. This scheme increases the rural doctor placement for at least a period of 2 years in rural area.

3.2.2 Assumption 2: definition of rural and urban areas.

There are many available definitions in the literature. As per the (Muula, 2007) explanation that 'a universal definition of a rural area is not possible'. Therefore, the definition concluded by (Couper, 2003) "as rural cannot be defined as non- urban', to define rural health care as the 'provision of health services to areas outside of

metropolitan centres where there is not ready access to specialist intensive and/or high technology care...'' is accepted. In our context, the data are collected from various sources so that the data on which we rely may not follow the definition as we have accepted here.

3.2.4 Assumption 4: Aging Chain of Doctors

We have assumed that doctors move along the aging chain through three stocks: rookies, semi-experienced and experienced, both for rural and urban setting. We chose to split the labour force in three group in order to show that doctors can choose two different types of paths after spending some time and gaining experience in their workplace either to stay or re-locate from rural to urban setting or vice versa on the basis of different decision variables under different stages of aging chain.

3.2.5 Assumption 5: Distinction between Registered Doctors and Practising Doctors

Sum of total rural and urban doctor does not match the total historical doctors. It is due to the fact the historical data of doctor account the total medical graduates who have obtained medical license after passing the NMC exams. But Total doctor calculated in using Total Doctor convertor only account for the total doctor currently employed in the rural and urban areas since register doctor are there in as doctor but are not allotted for rural or urban practice.

3.2.6 Assumption 6: Determinants of migration

Numerous factors determine the migration of the doctors between urban and rural areas (Zurn et al., 2002). All of these factors are not considered to specify model boundary and better understand some key determinant. Factors associated with additional financial income, learning opportunities and workload stress are considered as the main driving variables for the doctors' decision to migrate based on the literature reviewed on Chapter 2.

3.2.7 Assumption 7: Historical behaivor of total, rural and urban doctors

It should be noted that the urban doctors to urban population ratio and rural doctors to rural population ratio, total registered doctors and total medical college capacity used for the reference mode are based on some necessary assumption. Firstly, the classification of

urban doctors and rural doctors are 40% and 60% respectively based on the literature review and do not represent and exact data. Nevertheless, Total doctor represent the actual data which is distributed at 40:60 proportion between rural and urban based on the evidences from literature. It reflects only percentage representation while the real numbers of doctors in urban and rural throughout Nepal are unknown. Secondly, the initial value for the medical college capacity are estimated through backward calculation based on the year of establishment from college official website taking the reference value of year 2018 and 2019.

The data for total registered medical doctors was available for year 2000, year 2005, year 2008 and from year 2012 to year 2018 only, so the numbers in between the years were estimated using growth rate calculation as GR= (present year/past year)1/n-1) (further discussed in detail in the methodology part).

3.3 Model Structure

This section contains a detailed discussion of each components of the simulation models' structure in align with different theories applied and gives an explanation to how problem behaviour could be replicated without a policy structure. The different sectors of the model structure and the interactions between them is explained in detail.

3.3.1 Medical student sector

This sector is an adaptation from the work of (Ishikawa et al., 2013) that highlights the transition of new enrollment of students in medical graduates, training to enter the profession, choose his/her occupation area and practice clinical and after delay either take a leave or retirement. This concept best fits to the medical studies in Nepal.

Below is the figure that replicates the base concept for medical studies.

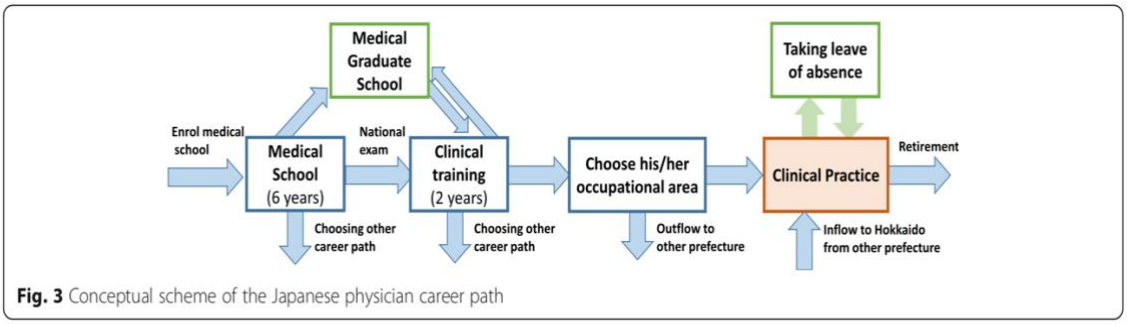

Figure 7. Adapted from (Ishikawa et al., 2013)

Also, (Huntington et al., 2012) explains that medical students in Nepal enter medical school after 12 years of primary and secondary school. Secondary schools are either free government schools, which predominate in rural areas or in urban areas among low-income families, or they are private fee-based institutions. Medical education in Nepal is a 5.5 years curriculum based on the British medical education model. Upon completion of 2 years of pre-clinical education and 2.5 years of clinical clerkships, students receive a MBBS degree. Additionally, one year of internship is required to sit for the Nepal Medical Council licensing exam, after which the graduate is licensed to practice medicine in Nepal. After passing the required exam, the medical doctors obtain their license and can start practicing in the location of their choice. To specialize further, newly graduated doctors must complete postgraduate training of several years, either in Nepal or abroad.

Based on the above literature, the medical student sector has been developed in terms of stock and flow diagram which is exhibited in Figure 8 below:

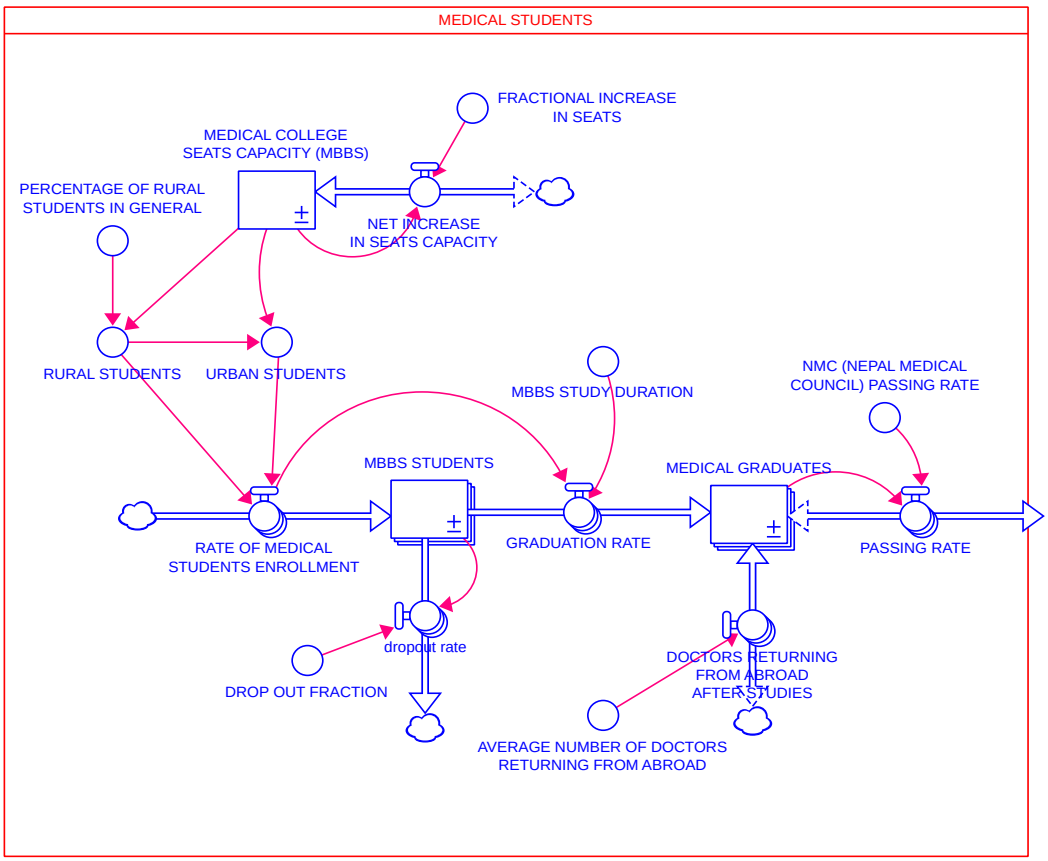

Figure 8. A general structure of medical students' sector

This sector generates the mechanism for how the medical seats are distributed to the students. The total number of enrolments of the medical students depends on the availability of medical college seats. The structure above represents the number of medical students recruited each year from secondary schools, determined by the seats allotted by Department of Health. The sufficient number of doctors are generated with the FRACTIONAL INCREASE IN THE MEDICAL SEATS depending on the college criteria and government rules. The MEDICAL COLLEGE SEATS CAPCITY is a stock for every year that increases with the inflow rate of FRACTIONAL INCREASE IN SEATS. As our model is mainly focused on the uneven distribution of doctors in rural and urban settings, it becomes important to distinguish in the beginning itself, the background of the students from their enrolment as RURAL STUDENTS and URBAN STUDENTS based on the PERCENTAGE OF RURAL STUDENTS IN GENERAL, an exogenous parameter.

As mentioned earlier, students with rural and urban backgrounds are enrolled which determines the RATE OF MEDICAL STUDENTS ENROLMENT every year

which is an inflow to the stock of MBBS STUDENTS. During that year, the stock can be depleted with some DROPOUT FRACTION. The DROP OUT FRACTION, exogenous parameter, is considered as 5.4 percent from the study on Bangladesh which is developing country like Nepal (Miah et al., 2014). In Nepal, on average student spent five and half years as medical student before graduating as a doctor. This delay is captured in the MBBS STUDY DURATION of medical school that controls the outflow from the stock level of MBBS STUDENTS. A typical depletion formulation is used in which the RATE OF GRADUATION is the ratio of MBBS MEDICAL STUDENTS to the MBBS STUDY DURATION. The flow of graduated students then accumulates in the pool of MEDICAL GRADUATES. Every year, those students who do not get seat to study the medical in Nepal go abroad and return after completing their studies. These students also accumulate in the MEDICAL GRADUATES stock. Finally, a significant number of registered doctors are produced as REGISTERED DOCTORS with annual NMC PASSING RATE from Nepal Medical Council (NMC).

3.3.2 Medical Doctor composition structure

This structure consists of a generic workforce configuration which is based on the skills classification of workers similar to the work of (Cosenz & Carmine, 2014) where the has been classified as rookie., medium skilled and skilled workers in this study. For our purpose of study, we define skills in particular as the doctors' experience based on the number of years of practice both in rural and urban location. Thus, the general doctor framework is distinguished as the following as depicted in Figure 9 below:

1**. ROOKIES**, as doctors at their first job experience, that are fresh graduates and registered doctors without any work experience. They do not have skills and expertise in their practice; thus, they need training and know how sharing with more skilled doctors in order to improve their skills.

2**. SEMI-EXPERIENCED DOCTORS**, includes those with some years of experience in the practice in any location, either rural or urban area. They offer their developed competencies to cure their patients. They have achieved a certain year of experience in their job career and are ready to provide training to rookies. Their productivity is higher than that of rookies but lower than that of skilled doctors. To reach to the next career level (Experienced doctors), they have to gain years of experiences in the practice and enhance

their skills and expertise through training and choosing the specialists study. The rookies require the same 2 years of practice to become semi experienced doctor.

3. **EXPERIENCED DOCTORS**, as 'veteran' doctors have developed relevant and wide competencies in the practice and study: this means that their expertise is the highest of the entire doctor's workforce. As experience doctors, they are also responsible to provide training to rookies.

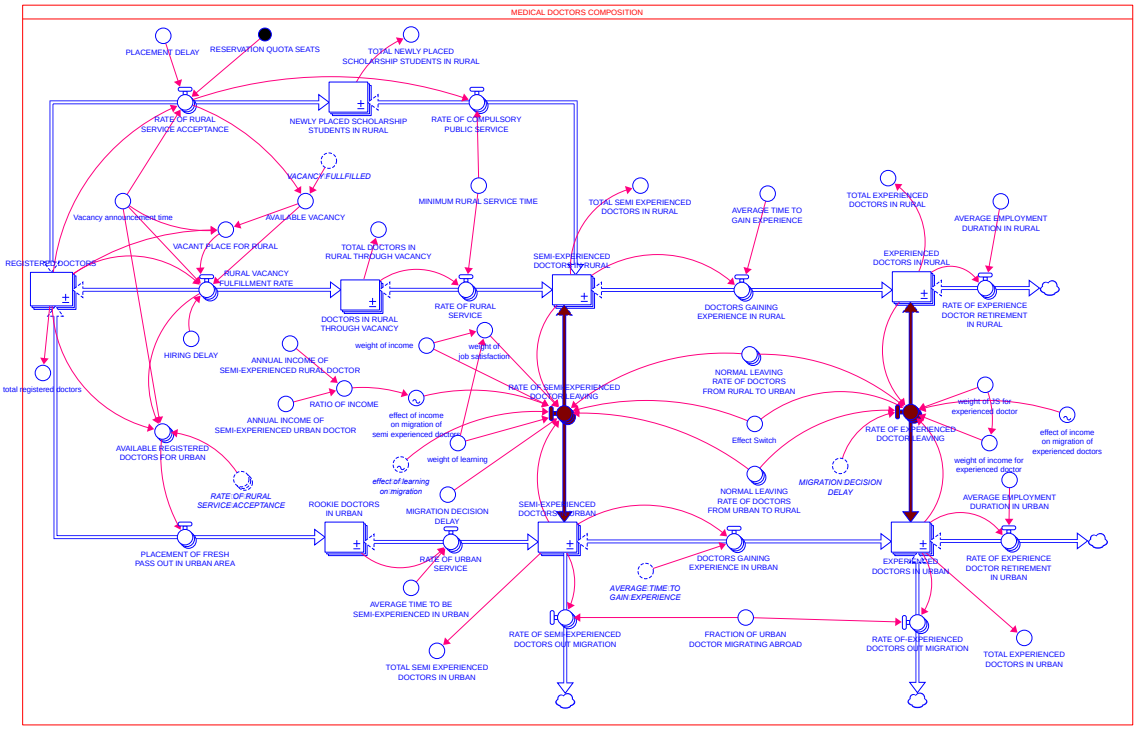

Figure 9. A general structure of medical doctor composition

As it has been already mentioned, different years of experience correspond to each doctors' category. In this way, give the number of years of experience, it is possible to determine the category of doctors under which they fall. A simplifying assumption is that doctors are always hired at the rookie's level and always retire from the experienced level. Since, there lacks number of doctors in rural therefore we have only tried to model the hiring process for RURAL VACANCY POSITIONS.

In this model, rookies are the NEWLY PLACED SCHOLARSHIP DOCTORS and DOCTORS THROUGH VACANCY in case of rural setting and it is clearly mentioned that ROOKIE DOCTORS IN URBAN for the urban. After getting the license to practice, the medical doctors who were under the scholarship scheme are bound to locate for work

in the rural area as agreed and stated in the Scholarship rule for a period of 2 year. The time to get placed and settled there requires a time of at least 1.5 year which is captured by the delay in the model. The RESERVATION QUOTA SEATS (scholarship scheme) go to the pool of NEWLY PLACED SCHOLARSHIP STUDENTS IN RURAL. Here, the students from either rural or urban background fall in this pool. After two year of compulsory public service in rural, they get into the stock of SEMI-EXPERIENCED DOCTORS IN RURAL. The doctors other than RESERVATION QUOTA SEATS and those who accepts the vacancy for rural location i.e. the stock of DOCTORS IN RURAL THROUGH VACANCY are likely to get employed in the urban area

The SEMI-EXPERIENCED DOCTORS IN RURAL also include the doctors through the vacancy posts. After rural service acceptance, the remaining vacancy positions are sanctioned and filled by the doctors. Generally, the vacancy announcement is done by MOHP and the Public Service Commission (PSC)[5] Nepal, this body advertise the required number of vacancy posts for doctors for different location and later distributes the filled vacancy posts to those respective location. In this model, it is assumed that the doctors through vacancy in rural setting requires MINIMUM RURAL SERVICE TIME OF 2 years of stay to be qualified as SEMI-EXPERIENCED DOCTORS IN RURAL. The RURAL VACANCY FULFILMENT RATE is affected by the VACANCY FULFILLED and the HIRING TIME. The delay created due to the long processing time is captured in the model. The process of vacancy for rural positions is shown in the Figure 10.

Thus, after gaining two years of experience, the stock of SEMI-EXPERIENCED DOCTORS IN RURAL either continue to work in rural and gain years of experience or they move to the urban setting. The decision of movement or continue to stay is affected by the various factors as mentioned in the literature above. The important factors decision variable for the SEMI-EXPERIENCED DOCTORS' LEAVING (movement or relocation) is the ***learning opportunities*** in terms of guidance, supervision and mentoring to continuing education (professional courses and workshops) from the senior experienced doctors. The ***income*** and ***work pressure*** & ***job satisfaction*** are the key factor for SEMI-EXPERIENCED DOCTORS to migration to and flow. The different weights

[5] https://psc.gov.np/

are assigned for ***effects of learning, income and work pressure*** & ***job satisfaction job satisfaction*** which is shown through the effects sector below in more detail. After the migration decision of SEMI-EXPERIENCED DOCTORS IN RURAL, they accumulate in the pool of SEMI-EXPERIENCED DOCTORS IN URBAN. Those who continue to work for 10 years of experience in rural becomes experienced doctors. The EXPERIENCED DOCTORS IN RURAL are also likely to migrate or leave the job in rural to relocate themselves in urban. The most important factor in consideration for such pool of doctors are the financial benefits and incentives. The extra income through dual practice has been stated in various paper. More the income earning opportunities, more the movement of experienced doctors to that location. Therefore, the decision of movement or migration of doctors rural to urban or urban to rural area are represented through the bi-flows concept in the model structure. The SEMI-EXPERIENCED and EXPERIENCED URBAN DOCTORS' stock gets depleted by the EMIGRATION RATE and RETIREMENT RATE.

3.3.3 Vacancy for rural positions

Every year there is a vacancy opening for medical officers by MOHP through PSC. The vacancy positions are mainly sanctioned for remote and rural positions. Every year new posts are created and sanctioned with certain RATE OF INCREASE IN VACANCY. The RATE OF INCREASE IN VACANCY, accumulates the stock of vacancy positions for rural placement every year. These opening of total VACANCY posts are fulfilled with certain VACANCY OCCUPANCY RATE as depicted in the Figure 10.

Later, the VACANCY FULFILLED affects the REMANINING VACANT POSITIONS which is detailed in medical doctor's composition structure above.

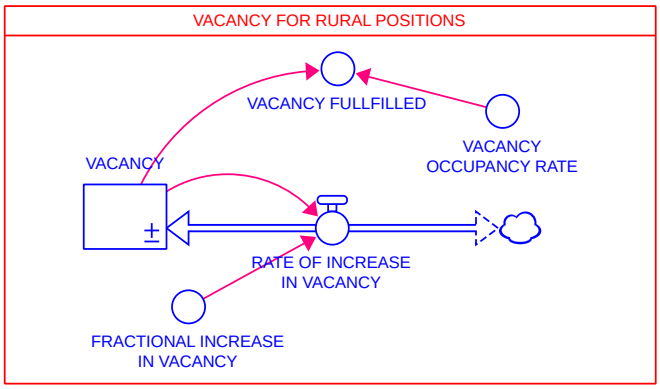

Figure 10. A general structure of vacancy of rural positions

3.3.4 The Learning effects

The relative learning effect on the initial migration fraction represents how differences between the learning in rural and urban (learning gap) affect decisions to migrate for doctors which is exhibit in Figure 11. A wider experienced staffing gap between the rural vs. urban increases the probability to migrate. According to (Pilon & Herweg, 2001); one of the factors that affect the ability to learn is the shortage of people or staffing gap. When new pool of rookie doctors are recruited or placed, new staff directly from medical school cannot contribute as much as the semi- experienced or experienced doctors. It takes on average two year to become fully semi-skilled and ten years to become experienced doctors both in case of urban and rural setting. During that period the semi-experienced doctors is scheduled in the same way as other experienced doctors. The lack of assistance, supervision and mentoring with work is affected by the presence of experienced doctors. More experienced doctor means more guidance and sharing in the work pressure, and thus more learning opportunities in workplace and vice versa. Thus, the fraction of semi-experienced to experienced rural doctor gives the measurement of learning and also same way is adopted to calculate learning opportunities in case of urban area.

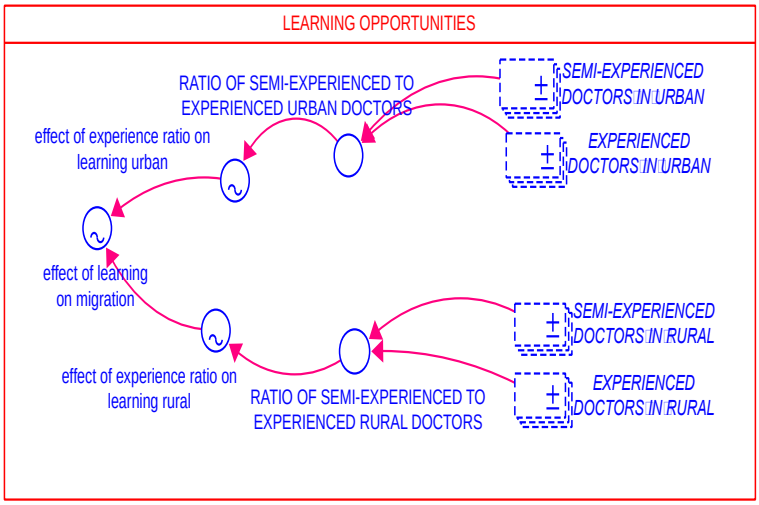

Figure 11. A general structure of learning effect

Figure 11. illustrates the learning process. The improvement in hiring and retention of experienced doctor in rural increases the chances for the semi-skilled doctors to continue to practice and serve the public in rural and thus reduces the learning gap which in turn lowers the propensity to migrate. As the gap narrows the migration outflow from the stock of SEMI-EXPERIENCED DOCTORS IN RURAL to SEMI-EXPERIENCED DOCTORS IN URBAN decreases for the reason of lack of learning opportunities.

For the LEARNING OPPORTUNTIES in rural area, more DOCTORS IN RURAL THROUGH VACANCY and NEWLY PLACED SCHOLARSHIP STUDENTS IN RURAL accumulates in semi experienced and further experienced doctors' stock in rural. In order to measure the learning in rural area, the ratios of RATIO OF SEMI-EXPERIENCED TO EXPERIENCED DOCTORS IN RURAL is compared. If the ratio is greater than 1, the SEMI-EXPERIENCED DOCTORS IN RURAL have less learning opportunities and tends to migrate from rural to urban and if the ratio of learning is lesser than 1, the SEMI-EXPERIENCED DOCTORS IN RURAL have more satisfactory learning opportunities and tend to stay in rural.

For the LEARNING OPPORTUNTIES in urban area, more semi experienced and experienced urban doctor would have no fear to accept the available job vacancies for the in urban and increasing the unbalance for the distribution. The RATIO OF SEMI-EXPERIENCED TO EXPERIENCED DOCTORS IN URBAN is greater than 1, the SEMI-EXPERIENCED DOCTORS IN URBAN have less learning opportunities and

tends to migrate abroad or in rural and if the ratio of learning is lesser than 1, the SEMI-EXPERIENCED DOCTORS IN URBAN have more satisfactory learning opportunities and tend to stay in urban. The relative learning effect for both rural and urban is modelled as a function of the learning ratio:

Relative learning effects = f (learning ratio of rural vs. urban)

The learning ratio (gap) is ratio of SEMI-EXPERIENCED TO EXPERIENCED DOCTORS IN RURAL and ratio of SEMI-EXPERIENCED to EXPERIENCED DOCTORS IN URBAN it is to be noted that there will always exists a gap between the number of semi-experienced and experienced doctors in rural and urban (minimum gap) representing no change in migration decisions. In other words, doctors from rural will not migrate until a significant learning difference exists. This study assumes that the learning gap narrows as the semi experienced and experienced rural doctor to semi experienced and experienced urban doctor ratio approaches the value of 1. A detailed method for the relationship estimations is included in Appendix A.

Relative learning opportunities is an important aspect for the semi-experienced doctors in both rural and urban. As learning ratio increase, willingness to migrate also rises. As the gap narrows, the willingness to migrate will decrease.

3.3.5 Additional Income and Salary (Dual Practice)

This sector presents the dynamics of additional salary and income of doctors through the dual practice in various hospitals and clinics. (Kiwanuka et al., 2011) defined dual practise as the holding of more than one job directly related to treating patients both in public and private within the health facility and outside it. The dual practice is triggered by the inadequate salary mostly in public health sector. In developing countries like Nepal, the tuition fees at medical school is very high in Nepal, so many students who were self-financed would like to get more return from their investments that influences their career choice location and those students after graduation is more likely to stay in urban area and earn more as stated in (P Ravi Shankar, 2010) work.

Generally, the public government hospitals are located in both urban and rural areas and privately-owned hospitals are urban centric. The government hospitals are often

overcrowded due to either charge a nominal fee or are free of charge to the citizens of the country, leading to high work pressure and shortages of medical doctors especially in rural location.

It is assumed that the citizens generally go to public hospitals to seek treatments and doctor consult the patients whether to walk-out or be admitted to the hospital for certain illnesses. These hospitals work at its full capacity (PUBLIC HOSPITAL CAPACITY) and if there is flow of patient beyond their capacity then only patients go to the private hospitals as shown in the structure below. Figure 12. depicts in detail how the mechanisms of additional income and salary works in dual practice and its effect on the migration decision.

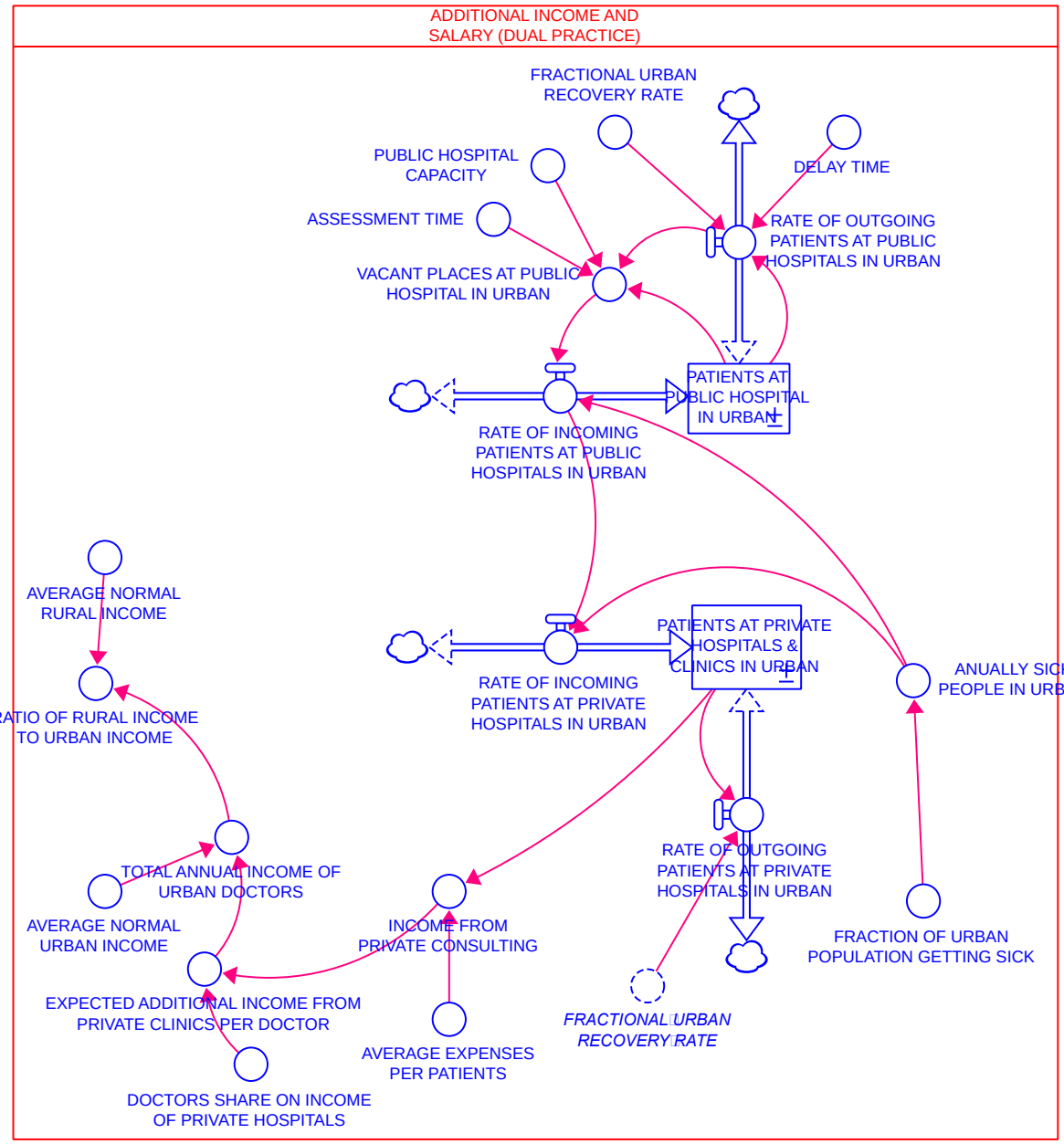

Figure 12. A general structure of additional income and salary (dual practice)

Here, the number of SICK PEOPLE IN URBAN is determined by the FRACTION OF URBAN POPULATION GETTING SICK out of TOTAL URBAN POPULATION. Thus, the number of PATIENTS AT PUBLIC HOSPITALS IN URBAN increases by the RATE OF INCOMING PATIENTS AT PUBLIC HOSPITALS IN URBAN and decrease by the RATE OF OUTGOING PATIENTS AT PUBLIC HOSPITALS IN URBAN. The private hospitals and clinics in urban receive the patients only when the public hospitals are operated at their full capacity. Therefore, the variable ‘‘PATIENTS AT PRIVATE HOSPITALS AND CLINICS IN URBAN” reflects the health status of the urban

population determined through remaining patients from the public hospitals. The RATE OF INCOMING PATIENTS AT PRIVATE HOSPITALS IN URBAN and the RATE OF OUTGOING PATIENTS AT PRIVATE HOSPITALS IN URBAN is same as the structure for PATIENTS AT PUBLIC HOSPITALS IN URBAN. Since there is a high tendency of urban doctors to engage in dual practice, the presence of urban concentrated private hospitals and clinics eases to earn the additional income to their basic salary. The AVERAGE EXPENSES PER PATIENTS and the total number of PATIENTS AT PRIVATE HOSPITALS AND CLINICS IN URBAN gives the INCOME FROM THE PRIVATE CONSULTING. The doctor EXPECTED ADDITIONAL INCOME comes from the agreed share per consultation fee (DOCTORS SHARE ON INCOME OF PRIVATE HOSPITALS). Thus, the TOTAL ANNUAL INCOME OF URBAN DOCTORS is the sum of INCOME FROM THE PRIVATE CONSULTING and AVERAGE NORMAL ANNUAL INCOME. The RATIO OF RURAL INCOME TO URBAN INCOME is calculated to analyse the relative INCOME EFFECTS ON MIGRATION. If the RATIO OF RURAL INCOME TO URBAN INCOME is less than 1, the SEMI-EXPERIENCED DOCTORS IN RURAL and EXPERIENCED DOCTORS IN RURAL migrate from rural to urban location and if the ratio is greater than 1, the SEMI-EXPERIENCED DOCTORS IN RURAL and EXPERIENCED DOCTORS IN RURAL would continue to work in rural whereas SEMI-EXPERIENCED DOCTORS IN URBAN and EXPERIENCED DOCTORS IN URBAN migrate from urban to rural location.

3.3.5.1 The income effects on migration

The relative income effect on the initial rate of experienced doctor leaving represents how differences between the average income in rural and urban (income gap) affect decisions to migrate. A wider income gap between the two locations increases the propensity to migrate thereby raising the NORMAL LEAVING RATE OF DOCTORS with rural background and urban background. Consequently, migration inflow rises adding more urban migrants. The improvement in the rural income level relative to the urban income level reduces the income gap which in turn lowers the propensity to migrate. Therefore, the normal leaving rate falls down reducing the migration inflow which adds less to experienced doctor in urban stock. And vice-versa. As the gap narrows the migration

inflow slows and stops for income reasons. The relative income effect is modelled as a function of the ratio of rural income to urban income:

Relative income effects = f(ratio of rural income to urban income).

The income ratio (gap) is a division of AVERAGE NORMAL RURAL INCOME relative to AVERAGE NORMAL URBAN INCOME in a year base (Income Ratio = average normal rural income / average normal urban income). It is noted that there is always a minimum income gap between these locations (rural vs. urban). In other words, that doctors will not migrate until a significant income difference exists. In this structure it is assumed that the income gap narrows as the ratio of rural to urban income approaches the value of 1. A detailed method for the effects of income in migration is included in Appendix A.

The Relative income effects is an important decision factor for potential experienced doctors to migrate from rural to urban. As income differences increase, willingness to migrate also rises. As the gap narrows, the willingness or decision to migrate will decrease.

3.3.6 Work Pressure and Job Satisfaction

Figure 13. demonstrates the work pressure of rural doctors relative to work pressure stress of urban doctors and its effect on the job satisfaction. These pressure are measured in terms of the RATIO OF ACTUAL TO STANDARD PATIENTS and RATIO OF ACTUAL INCOME TO STANDARD INCOME PER PATIENT treated both in rural and urban area.

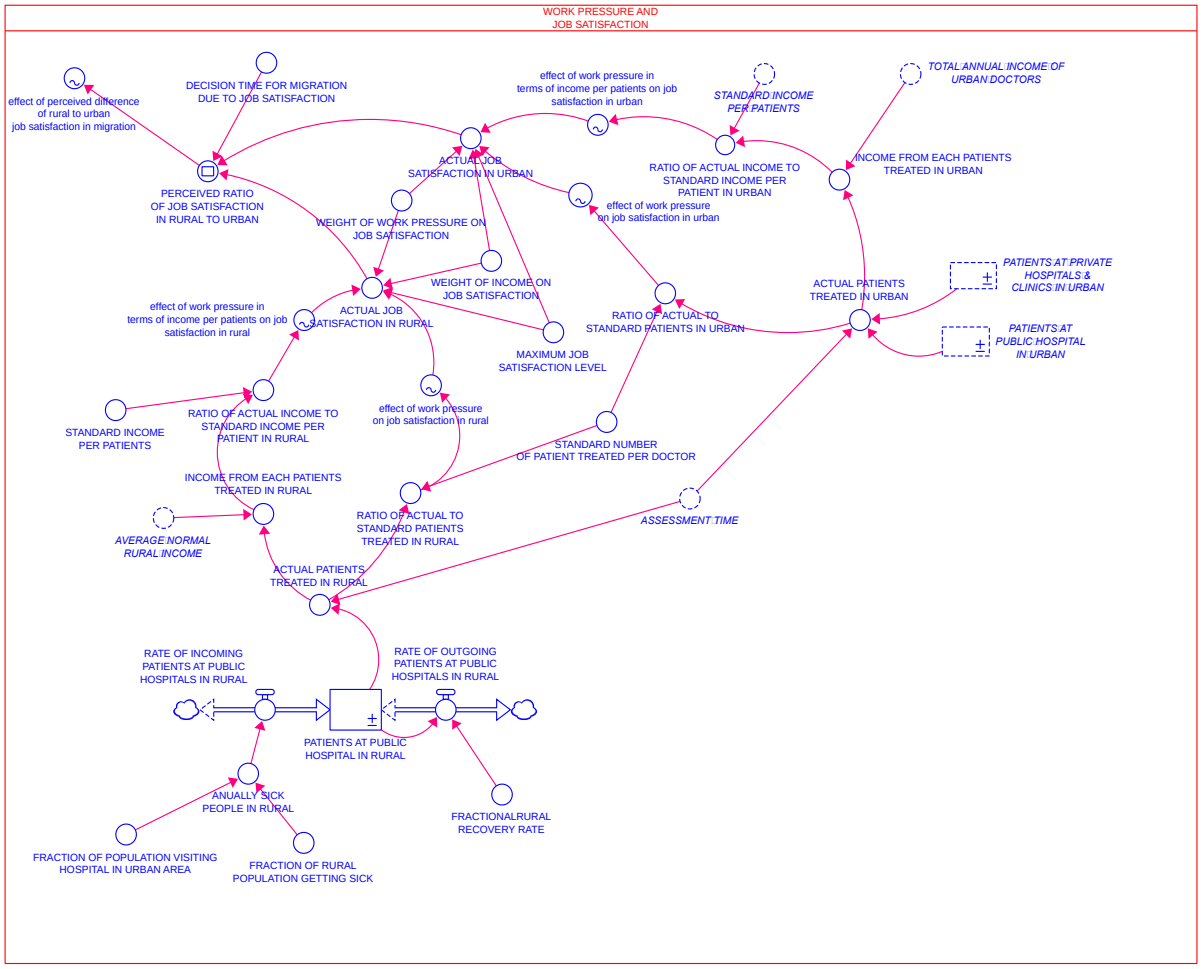

Figure 13. A general structure of Work Pressure and job satisfaction

As already mentioned earlier, there are only government hospitals in rural area and these hospitals are also often overcrowded because these hospitals are cheaper and within the reach of poor people due to free of charge or a nominal fee. Thus, it leads to high workload among the doctors in rural. Here, the number of SICK PEOPLE IN RURAL is determined by the FRACTION OF RURAL POPULATION GETTING SICK out of TOTAL RURAL POPULATION. Thus, the number of PATIENTS AT PUBLIC HOSPITALS IN RURAL increases by the RATE OF INCOMING PATIENTS AT PUBLIC HOSPITALS IN RURAL and DECREASE BY THE RATE OF OUTGOING PATIENTS AT PUBLIC HOSPITALS IN RURAL. The ACTUAL PATIENTS TREATED IN RURAL is the total number of patients treated by the TOTAL DOCTORS IN RURAL. Here, the actual is compared to standard patients in order to represents the relative work pressure. If the RATIO OF ACTUAL TO STANDRAD PATIENTS IN RURAL is greater than 1, the doctor has a greater work pressure but if it is less than 1, there is no pressure at all in rural

in terms of number of patients. Similarly, RATIO OF ACTUAL INCOME TO STANDARD INCOME PER PATIENT IN RURAL represents the number of patients treated in terms of per rupee income relative to the STANDARD INCOME PER PATIENTS to measure the Work Pressure in terms of monetary units. The different weight has been assigned for WEIGHT OF WORK PRESSURE ON JOB SATISFACTION and WEIGHT OF INCOME ON JOB SATISFACTION. Later the EFFECT OF WORK PRESSURE IN TERMS INCOME PER PATIENTS ON JOB SATISFACTION IN RURAL is obtained in terms of graphical function. As we know greater the work pressure lowers the job satisfaction and vice versa. If the RATIO OF ACTUAL INCOME TO STANDARD INCOME PER PATIENT IN RURAL is lower than 1, there is more work pressure meaning the doctors get less amount of money treating more number of patient, which results to decline in job satisfaction and if the RATIO OF ACTUAL INCOME TO STANDARD INCOME PER PATIENT IN RURAL is greater than 1, there is less workload meaning the doctors get more amount of money treating less number of patient, which results to increase in job satisfaction in rural location.

Both the EFFECT OF WORKPRESSURE in terms of number of patients treated and INCOME PER PATIENTS ON JOB SATISFACTION is calculated to analyse the ACTUAL JOB SATISFACTION IN RURAL. The ACTUAL JOB SATISFACTION IN RURAL is the product of NORMAL JOB SATISFACTION IN RURAL, EFFECT OF WORK PRESSURE IN TERMS OF INCOME PER PATIENTS ON JOB SATISFACTION IN RURAL and EFFECT OF WORK PRESSURE ON JOB SATISFACTION IN RURAL.

More public hospitals and private hospitals & clinics are concentrated in cities and urban area with better infrastructure and facilities. The public hospitals are better equipped. The patients are over flooded in both public and private hospitals and clinics. So, the number of total patients treated are the sum of PATIENTS AT PUBLIC HOSPITALS IN URBAN and PATIENTS AT PRIVATE HOSPITLAS & CLINICS IN URBAN. More detailed explanation for this section is presented in the ADDITIONAL INCOME AND SALARY (DUAL PRCATIVCE) sector. The ACTUAL PATIENTS TREATED IN URBAN is the total number of patients treated in both PUBLIC AND PRIVATE HOSPITALS & CLINICS by the TOTAL DOCTORS IN URBAN. Here, the actual is compared to standard patients in order to represents the relative work pressure. If the RATIO OF

ACTUAL TO STANDRAD PATIENTS IN URBAN is greater than 1, the doctor has a greater work pressure but if it is less than 1, there is no pressure at all in urban in terms of number of patients. Similarly, RATIO OF ACTUAL INCOME TO STANDARD INCOME PER PATIENT IN URBAN represents the number of patients treated in terms of per rupee income relative to the STANDARD INCOME PER PATIENTS to measure the Work Pressure in terms of monetary units. Later the EFFECT OF WORK PRESSURE IN TERMS INCOME PER PATIENTS ON JOB SATISFACTION IN URBAN is obtained. As we know greater the work pressure lowers the job satisfaction and vice versa. If the RATIO OF ACTUAL INCOME TO STANDARD INCOME PER PATIENT IN URBAN is lesser than 1, there is more work pressure meaning the doctors get the less amount of money treating more number of patient, which results to decline in job satisfaction and if the If the RATIO OF ACTUAL INCOME TO STANDARD INCOME PER PATIENT IN URBAN is greater than 1, there is less workload meaning the doctors get the more amount of money treating less number of patient, which results to increase in job satisfaction in urban location.

The relative job satisfaction due to workload pressure between rural and urban area is the ratio between ACTUAL JOB SATISFACTION IN RURAL and ACTUAL JOB SATISFACTION IN URBAN. It takes some time for building and adjusting the perceptions on job satisfaction and its ratio. The adjustment process will take place over a time delay defined as perception time of 3 years. It is the smoothed value of the incremental accumulation of perceived ratio of job satisfaction. This perceived ratio has an effect on the migration decisions. If the ACTUAL JOB SATISFACTION IN RURAL and ACTUAL JOB SATISFACTION IN URBAN is lower than 1, the SEMI-EXPERIENCED DOCTORS IN RURAL and EXPERIENCED DOCTORS IN RURAL migrate from rural to urban location and if the ratio is greater than 1, the SEMI-EXPERIENCED DOCTORS IN URBAN and EXPERIENCED DOCTORS IN URBAN migrate from urban to rural location. Therefore, the EFFECTS OF PERCEIVED DIFFERENCE OF RURAL TO URBAN JOB SATISFACTION IN MIGRATION is analysed and explained in detailed (Appendix A.)

3.3.6.1 The Work Pressure & Job Satisfaction Effects on Migration

The work pressure effect on the initial rate of semi-experienced and experienced doctor leaving represents how perceived relative differences between the ACTAUL JOB

SATISFACTION in rural and urban affect decisions to migrate. A wider perceived job satisfaction gap between these two locations increases the propensity to migrate thereby raising the NORMAL LEAVING RATE OF DOCTORS with rural background and urban background. Consequently, migration inflow rises adding more urban migrants. The reduction in workload in the rural area increases the job satisfaction and thus result to lower chances to migrate to the urban. Therefore, the normal leaving rate falls down reducing the migration inflow which adds less to semi- experienced and experienced doctor in urban stock and vice-versa. As the gap narrows the migration inflow slows and the doctors in rural are more likely to stay in rural. The job satisfaction effect is modelled as a function of the RATIO OF JOB SATISFACTION IN RURAL TO URBAN:

Relative Perceived job satisfaction effects = f (ratio of actual job satisfaction in rural to actual job satisfaction in urban income).

The perceived ratio of job satisfaction (gap) is a SMOOTH Function with a division of ACTAUL JOB SATISFACTION IN RURAL relative to ACTAUL JOB SATISFACTION IN URBAN INCOME in a year. It is noted that there is always a minimum perception gap in job satisfaction between these locations (rural vs. urban). In other words, that doctors will not migrate until a significant job satisfaction difference exists. In this structure it is assumed that the job satisfaction gap narrows as the ratio of rural to urban job satisfaction approaches the value of 1. More detailed on the estimation of the limits of effects of job satisfaction on migration is explained in documentation. (Appendix A.)

3.3.7 Population sector

Since the purpose of the model is to capture the dynamics behind uneven distribution of doctors in rural and urban, we need to incorporate a population sector. The stock of RURAL POPULATION and URBAN POPULATION are associated with the inflow of CRUDE BIRTH RATE and outflow of the CRUDE DEATH RATE for each location. The movement from rural to urban are captured through RURAL TO URBAN MIGRATION FRACTION. Out of the stock of URBAN POPULATION people usually do the international migration. The stock gets depleted by the outflow OUT MIGRATION RATE.

Here, the TOTAL DOCTORS IN RURAL are the sum of REGISTERED DOCTORS (rural background), NEWLY PLACED SCHOLARSHIP STUDENTS IN RURAL, DOCTORS IN RURAL THROUGH VACANCY, SEMI-EXPERIENCED DOCTOR IN RURAL and EXPERIENCED DOCTORS IN RURAL. The TOTAL DOCTORS IN URBAN are the sum of REGISTERED DOCTORS (urban background), ROOKIE DOCTORS IN URBAN, SEMI-EXPERIENCED DOCTOR IN URBAN and EXPERIENCED DOCTORS IN URBAN. Thus, RURAL DOCTOR TO RURAL POPULATION RATIO is the ratio between TOTAL DOCTORS IN RURAL and RURAL POPULATION. Similarly, URBAN DOCTOR TO URBAN POPULATION RATIO is the ratio between TOTAL DOCTORS IN URBAN and URBAN POPULATION. Therefor these ratios are compared to show the uneven distribution of doctors in Nepal.

Various study in South Asia revealed that physician supply impacts CRUDE DEATH RATE. Therefore, we try to consider this relationship between the doctor supply and crude death rate in our structure. The sector does not contain an endogenous structure that would portray the feedback from the supply of doctors to crude birth rate. The study from (Shetty & Shetty, 2014) concluded that the doctors per capita (primary health care physician) had an inverse association with mortality rate (CRUDE DEATH RATE). In other words, the country with the best population physician ratio had the best mortality indices. It is argued that more emphasis should be given to primary health care and equitable distribution of resources.

The data from Nepal revealed that improved health outcomes in terms of mortality rate is associated with physician supply and an increase of one primary care physician per 10,000 population. This change effect is captured by using elasticity of crude death rate to total doctors' supply in urban and rural location. The detailed structure is exhibit in figure 14. below:

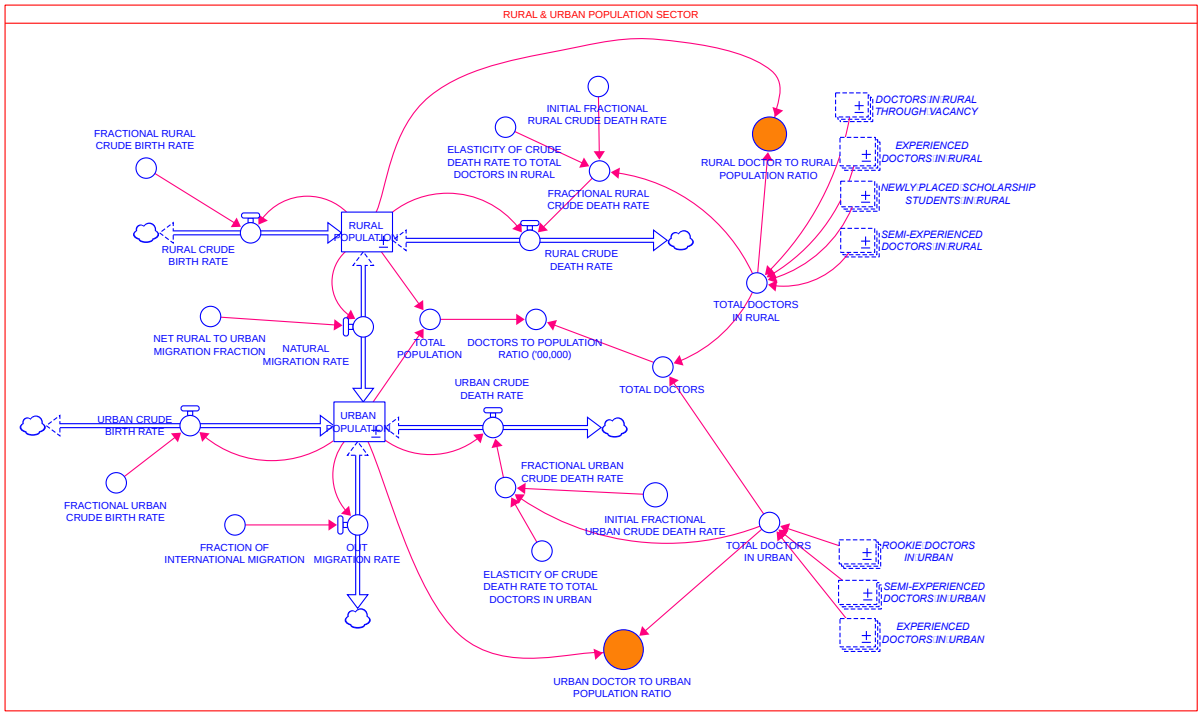

Figure 14. A general structure of rural and urban population sector

The population sector also gives the doctor per 10000 population for rural area and urban area separately. The TOTAL POPULATION is sum of RURAL POPULATION and URBAN POPULATION. The TOTAL DOCTORS are the sum of TOTAL DOCTORS IN RURAL AND TOTAL DOCTIRS IN URBAN. Thus, DOCTORS TO POPULATION RATIO (00,000) is calculated by TOTAL DOCTORS/ TOTAL POPULATION.

3.4 Feedback Perspective

The following CLD shows the feedback structure underlying the uneven distribution of doctors in Nepal (rural vs. urban). This pattern of migration behavior is the outcome of interactions between eleven major feedback loops that represent the combined effects of all the variables discussed in this chapter. Figure 15 is the detailed explanation to the underlying structure and its behaviour from the interactions among different variables.

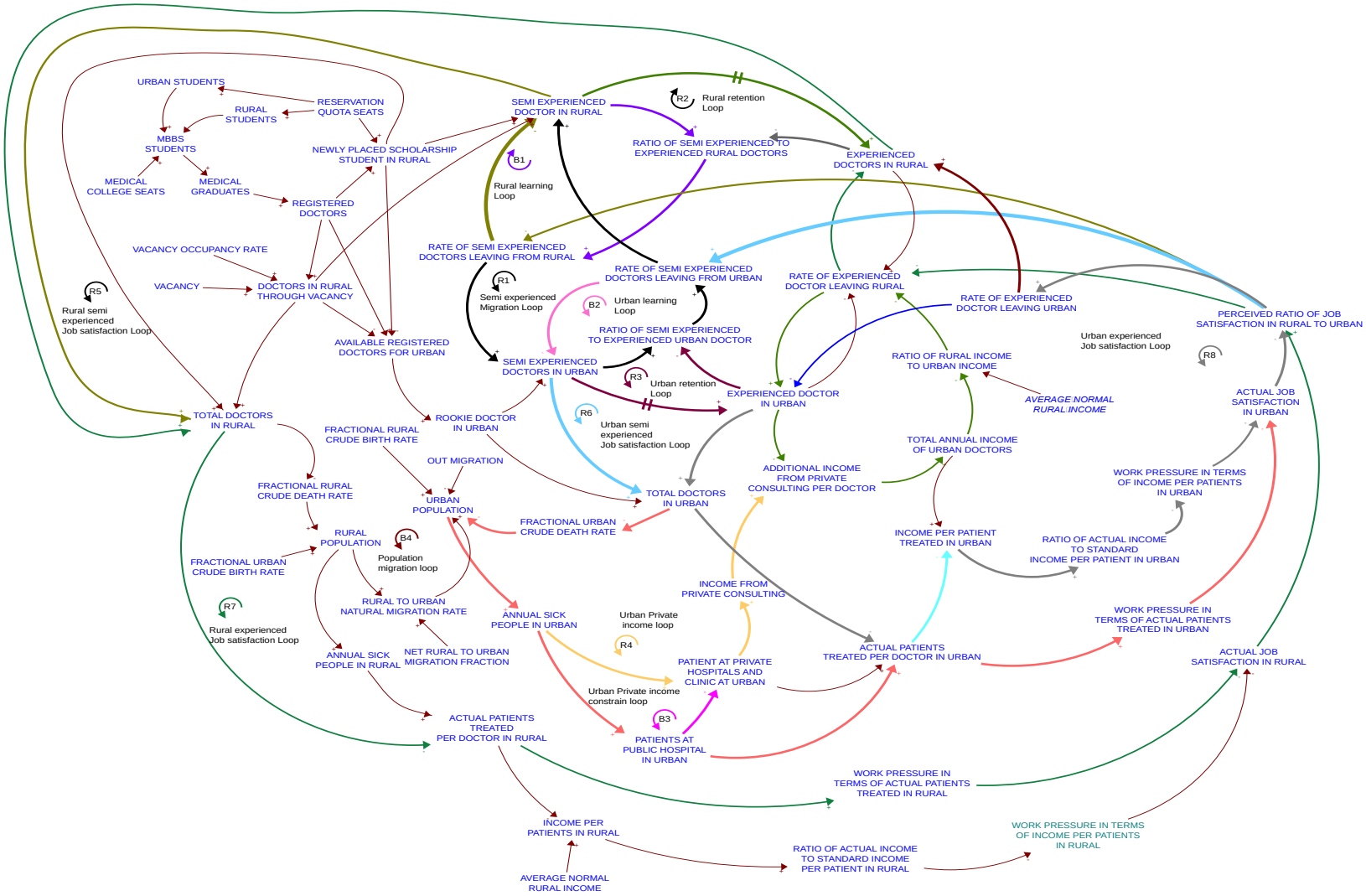

Figure 15. The simulation model with underlying feedback loops (Causal Loop Diagram)

R1- SEMI EXPERIENCED MIGRATION LOOP	The SEMI EXPERIENCED MIGRATION LOOP tends to explain the reason for the migration of SEMI EXPERIENCED DOCTOR IN RURAL and SEMI EXPERIENCED DOCTOR IN URBAN to and from. As SEMI EXPERIENCED DOCTOR IN RURAL increases RATIO OF SEMI EXPERIENCED TO EXPERIENCED RURAL DOCTOR increases which increases the RATE OF SEMI EXPERIENCED DOCTORS LEAVING FROM RURAL. This increases in leaving rate increases the number of SEMI EXPERIENCED DOCTORS IN URBAN which increases the RATIO OF SEMI EXPERIENCE TO EXPERIENCED URBAN DOCTOR consequently increasing RATE OF SEMI EXPERIENCED DOCTORS LEAVING FROM URBAN. This increase in RATE OF SEMI EXPERIENCED DOCTOR LEAVING FROM URBAN closes the loop further increasing the SEMI EXPERIENCED DOCTORS IN RURAL. This loop is a vicious cycle that either increases the semi experienced doctor in rural or urban area depending on the strength of on balancing loop governing the learning of semi-experienced rural and urban doctor explained below.
B1- RURAL LEARNING LOOP	This loop drives the strength of the R1 LOOP which drives the movement of semi

	experienced doctors from rural to urban or vice versa. As SEMI EXPERIENCED DOCTOR IN RURAL increases RATIO OF SEMI EXPERIENCED TO EXPERIENCED RURAL DOCTOR which increases the RATE OF SEMI EXPERIENCED DOCTOR LEAVING FORM RURAL resulting to a decrease in SEMI EXPERIENCED DOCTOR IN RURAL.
R2-RURAL RETENTION LOOP	This loop determines the increasing goal of the RURAL LEARNING LOOP. As SEMI EXPERIENCED DOCTOR IN RURAL increases, after significant delay, EXPERIENCED DOCTORS IN RURAL which decreases the RATIO OF SEMI EXPERIENCED TO EXPERIENCED RURAL DOCTORS which further decreases the RATE OF SEMI EXPERIENCED DOCTORS LEAVING FROM RURAL resulting to higher SEMI EXPERIENCED DOCTOR IN RURAL and further increasing EXPERIENCED DOCTORS IN RURAL
B2- URBAN LEARNING LOOP	Similar to RURAL LEARNING LOOP, this loop drives the strength of the R1 LOOP which drives the movement of semi experienced doctors from rural to urban or vice versa. As SEMI EXPERIENCED DOCTOR IN URBAN increases the RATIO OF SEMI EXPERIENCED TO EXPERIENCED URBAN DOCTOR which increases the RATE OF SEMI EXPERIENCED DOCTOR LEAVING

	FORM URBAN resulting to a decrease in SEMI EXPERIENCED DOCTOR IN URBAN.
R3-URBAN RETENTION LOOP	This loop acts in a same manner as the RURAL RETENTION LOOP but for the urban sector. This loop reinforces the EXPEREINCED DOCTOR IN URBAN by decreasing the RATIO OF SEMI EXPERIENCED TO EXPERIENCED URBAN DOCTOR and reducing the RATE OF SEMI EXPERIENCED DOCTOR LEAVING FORM URBAN ultimately increasing the EXPEREINCED DOCTORS IN URBAN through higher retention of SEMI EXPERIENCED DOCTOR IN URBAN. The loop discussed so far are crucial in determining the movement of semi experienced doctor between rural and urban area depending upon the strength gained by each loop due to the effect of these loops as well as other loops that effect the movement of experienced doctor to and from rural and urban sector.
R4-URBAN PRIVATE INCOME LOOP	One of the major determinants governing the migration of doctor is income. This loop aims to capture the effect of income on the migration of both semi-experienced and experienced doctor from rural to urban and vice versa. This loop can be traced starting from TOTAL DOCTORS IN URBAN, which increases with the increase in SEMI

	EXPERIENCED DOCTORS IN URBAN and EXPERIENCED DOCTORS IN URBAN. As TOTAL DOCTORS IN URBAN increases, FRACTIONAL URBAN CRUDE DEATH RATE decreases resulting in higher URBAN POPULATION. Assuming exogenous FRACTIONAL RURAL CRUDE BIRTH RATE and FRACTION OF PEOPLE GETTING SICK IN URBAN, ANNUAL SICK PEOPLE IN URBAN increases due to increase in URBAN POPULATION. As ANNUAL SICK PEOPLE IN URBAN increases PATIENT AT PRIVATE HOSPITAL AND CLINIC AT URBAN increase, under assumption that public hospital at urban have a fixed patient capacity. With the increase in PATIENTS AT PRIVATE HOSTPITAL AND CLINIC AT URBAN, INCOME FROM PRIVATE CONSULTING increases which further increases the TOTAL ANNUAL INCOME OF URBAN DOCTOR. This decreases the RATIO OF RURAL INCOME TO URBAN INCOME making urban migration favourable for experienced rural doctors determined by increase in RATE OF EXPEREINCED DOCTORS LEAVING RURAL. This increases the EXPERIENCED DOCTORS IN URBAN and closes the reinforcing loop by increasing the TOTAL DOCTORS IN URBAN.

B3- URBAN PRIVATE INCOME CONSTRAIN LOOP	URBAN PRIVE INCOME LOOP, discussed above, reinforces additional income for urban doctors resulting to higher migration of doctors from rural to urban. While, URBAN PRIVATE INCOME CONSTRAIN LOOP brings a control to the limitless increase in the rural to urban migration of doctors. This loop follows the same path as that of R4, but it increases the PATIENT AT PUBLIC HOSPITAL IN URBAN with the increase in ANNUAL SICK PEOPLE IN URBAN.
Job satisfaction is also among one of the factors that drive the movement of doctors from rural to urban or vice versa. Job satisfaction for doctor, here, is affected by two ways- work pressure in terms of actual patients and work pressure in terms of income per patients in rural. These two determinants for job satisfaction are driven by the loops discussed in the following section.	
R5- RURAL SEMI EXPERIENCED JOB SATISFACTION LOOP	This loop connects the elements that drive the job satisfaction of rural semi experienced doctors. In order to trace this, we start with the increases in SEMI EXPERIENCED DOCTOR IN RURAL which increases TOTAL DOCTORS IN RURAL. As TOTAL DOCTORS IN RURAL increases ACTUAL PATIENTS TREATED PER DOCTOR IN RURAL decreases. Decrease in ACTUAL PATIENT TREATED PER DOCTOR IN RURAL results to higher INCOME PER PATIENTS IN RURAL and lower WORK PRESSURE IN TERMS OF ACTUAL PATIENTS TREATED IN RURAL. Higher INCOME PER DOCTOR IN RURAL improves the RATIO OF

	ACTUAL INCOME TO STANDARD INCOME PER PATIENT IN RURAL, assuming an exogenous STANDARD INCOME PER PATIENT, resulting in decreased WORK PRESSURE IN TERMS OF INCOME PER PAITENTS IN RURAL. Lower work pressure both in terms of income per patients and actual patient treated improves ACTUAL JOB SATISFACTION IN RURAL and consequently improve PERCEIVED RATIO OF JOB SATISFACTION IN RURAL TO URBAN. Such improved perceived ratio of job satisfaction decreases the RATE OF SEMI EXPERIENCED DOCTORS LEAVING FORM RURAL resulting to higher SEMI EXPERIENCED RURAL DOCTOR and finally closing the loop.
R6- URBAN SEMI EXPERIENCED JOB SATISFACTION LOOP	This loop follows the same casualty as that of for the R5 while the only difference is the initial variable. Here, the loop starts with the increase in SEMI EXPERIENCED DOCTORS IN URBAN which increases TOTAL DOCTORS IN URBAN, then decreases ACTUAL PATIENTS TREATED PER DOCTOR IN URBAN which increases INCOME PER PATIENT TREATED IN URBAN. Increase INCOMEP PER PATIENT TREATED IN URBAN increases the RATIO OF ACTUAL INCOME TO STANDARD INCOME PER PATIENT IN URBAN. Increase in this ratio decreases WORK PRESSURE IN TERMS OF

	INCOME PER PATIENTS IN URBAN, assuming exogenous standard income per patient, and increases ACTUAL JOB SATISFACTION IN URBAN which decreases PERCEIVED RATIO OF JOB SATISFACTION IN RURAL TO URBAN and further decreases the RATE OF SEMI EXPERIENCED DOCTOR LEAVING FROM URBAN. Decrease in this rate closes the loop by increasing the SEMI EXPERIENCED DOCTORS IN URBAN.
R7-RURAL EXPERIENCED JOB SATISFACTION LOOP	Similar to R5, this loop drives the job satisfaction of rural experienced doctors. We start with the increase in EXPERIENCED DOCTOR IN RURAL which increases TOTAL DOCTORS IN RURAL. As TOTAL DOCTORS IN RURAL increases ACTUAL PATIENTS TREATED PER DOCTOR IN RURAL decreases. Now following the same path as R5, i.e. decreased ACTUAL PATIENT TREATED PER DOCTOR IN RURAL, higher INCOME PER PATIENTS IN RURAL, lower WORK PRESSURE IN TERMS OF ACTUAL PATIENTS TREATED IN RURAL consequently higher INCOME PER DOCTOR IN RURAL and higher RATIO OF ACTUAL INCOME TO STANDARD INCOME PER PATIENT IN RURAL, assuming an exogenous STANDARD INCOME PER PATIENT, resulting in decreased WORK PRESSURE IN TERMS OF INCOME PER PAITENTS IN RURAL

	which improves ACTUAL JOB SATISFACTION IN RURAL and consequently improve PERCEIVED RATIO OF JOB SATISFACTION IN RURAL TO URBAN. Such improved perceived ratio of job satisfaction improve decreases the RATE OF EXPERIENCED DOCTORS LEAVING FORM RURAL resulting to higher EXPERIENCED RURAL DOCTOR and finally closing the loop.
R8- URBAN EXPERIENCED JOB SATISFACTION LOOP	This loop drives the job satisfaction of urban experienced doctors. We start with the increase in EXPERIENCED DOCTOR IN URBAN which increases TOTAL DOCTORS IN URBAN. As TOTAL DOCTORS IN URBAN increases ACTUAL PATIENTS TREATED PER DOCTOR IN URBAN decreases. Now following the same path as R6, i.e. decreased ACTUAL PATIENT TREATED PER DOCTOR IN URBAN, higher INCOME PER PATIENTS IN URBAN, lower WORK PRESSURE IN TERMS OF ACTUAL PATIENTS TREATED IN URBAN consequently higher INCOME PER DOCTOR IN URBAN and higher RATIO OF ACTUAL INCOME TO STANDARD INCOME PER PATIENT IN URBAN, assuming an exogenous STANDARD INCOME PER PATIENT, resulting in decreased WORK PRESSURE IN TERMS OF INCOME PER PAITENTS IN URBAN which improves ACTUAL JOB SATISFACTION IN URBAN and

	consequently improve PERCEIVED RATIO OF JOB SATISFACTION IN URBAN TO RURAL. Such improved perceived ratio of job satisfaction improve decreases the RATE OF EXPERIENCED DOCTORS LEAVING FORM URBAN resulting to higher EXPERIENCED URBAN DOCTOR and finally closing the loop.
B4/R9-POPULATION MIGRATION LOOP	This loop either reinforces or balances the migration of RURAL POPULATION to URBAN POPULATION. As a minor balancing loop in itself it can be followed as: with the increases in RURAL POPULATION, RURAL TO URBAN NATURAL MIGRATION RATE increases, for the exogenous NET RURAL TO URBAN MIGRATION FRACTION. This loop then interacts with other reinforcing loops, mainly, R5, R6, R7 and R8 and depending on the strength of these loop increases RURAL POPULATION or decreases RURAL POPULATION. Thus, the loop changes its nature based on the strength of other loops which grounds the effects of all other loops described above in determining the problematic behavior.

Table 2. Explanation to feedback loops

Chapter 4: Validation

4.1 Model Validation

The concept of model validation in System Dynamics is controversial: there is no formally accepted list of tests an SD model has to pass to be considered validated(Sterman, 2000) According to Forrester, the core core principles of SD model validation are structure, behavior and policy sensitivity tests. According to (Barlas, 1996) the primary reason for checking validity of any model is to build the soundness of the model with respect to its purpose. The validation process builds the confidence in the model.

In order to validate any model, Barlas suggested a logical sequence as a guideline for carrying out model validity tests in three stages:

- Direct structural tests,
- Structure-oriented behavior tests, and
- Behavior tests.

Based on formal procedures outlined by (Barlas, 1996) the study conducts the model validity tests and the following is a brief explanation of the validation results.

4.2 Direct Structural Validity Tests

The major task has been constructing a model by mapping how the real system works that replicates historical medical doctors' internal migration patterns of behavior based on literatures and authentic data sources. So, for this study, direct structure tests are conducted by comparing each equation and logical function in the model based on the available theoretical or empirical knowledge about the aspect of the system being modelled and excludes any kind of simulations as stated by (Barlas, 1996). There are three direct structure tests for the model's validation based on empirical test: a structure confirmation test, a parameter confirmation test, and dimensional consistency test.

Structure confirmation test

Structure confirmation for this research began with the conceptualization of mental model based on intensive literature review of articles, reports, journals from various national, international scholars and views of related filed expert has been included. All the reviewed literatures articles for this research purpose had already been presented in detail in Chapter 2 and the transformation of Theoretical frameworks outlined in the literature were extensively used and presented in the model's structure has been done in Chapter 2. Since, model building is an iterative process, the model structure has been adjusted or changed during testing.

For example, while modelling the SEMI EXPERIENCED DOCTORS LEAVING RATE for both rural doctors and urban doctors, only LEARNING EFFECTS and WORK PRESSURE & JOB SATISFACTION EFFECTS were stated to be important factors for the doctors' decision whether to migrate or stay in rural or urban area. However, later with extensive review and model discussion with medical doctors, it was identified that SALARY AND INCOME also plays a major role for doctors' movement. So, ADDITIONAL INCOME AND SALARY EFFECTS has also been modelled for SEMI-EXPERIENCED DOCTORS LEAVING RATE.

Parameter Confirmation Test

Based on the real-world data, the initialization of stocks and parameters value were done. The various reliable government publications, reports, international organization data were extracted for this test purpose. The estimated parameters specially, MAXIMUM JOB SATISFACTION, the graph function was all estimated using literature review on various journals and research paper. The DELAY TIME, VACANCY ANNOUNCEMENT TIME, ASSESSEMENT TIME, PLACEMENT DELAY etc. are the terminologies used in real practice. More details about all the parameters are presented with relevant data sources in documentation to the model in Appendix A.

Direct extreme-condition Test

In this test, the validity of model equations under extreme conditions is evaluated, by assessing the credibility of the resulting values against the knowledge/anticipation of what would happen under a similar circumstance in realistic (Barlas, 1996) This test can be explained with an example for AVAILABLE REGISTERED DOCTORS FOR URBAN (background) for both

rural students and urban students. This parameter is an important variable for determining PLACEMENT OF FRESH PASS OUT IN URBAN AREA. It is formulated by the following equation:

AVAILABLE_REGISTERED_DOCTORS_FOR_URBAN=MAX(0,
REGISTERED_DOCTORS/VACANCY_ANNOUNCEMENT_TIME-
RATE_OF_RURAL_SERVICE_ACCEPTANCE-
RURAL_VACANCY_FULFILLMENT_RATE)

This formulation explains that in reality the number of fresh doctors who are willing to practice in urban area can never be negative. Thus, MAX function is used to regulate the value of AVAILABLE REGISTERED DOCTORS FOR URBAN. This means the AVAILABLE REGISTERED DOCTORS FOR URBAN is either maximum value of zero or the remaining REGISTERED DOCTORS after RATE OF RURAL SERVICE ACCEPTANCE which is allotted through the scholarship scheme (RESERVATION QUOTA SEATS) for compulsory 2 years bonding rural service and RURAL VACANCY FULFILLMENT RATE for rural vacancy.

Dimensional Consistency Test

The dimensional consistency test assesses whether the equations are dimensionally consistent within the model without using any "dummy" parameters that do not exist in the real system (Barlas, 1996)&(Sterman, 2000). The isee system' Stella Architect software where the SD model has been developed is used for this dimensional test. This software has built in function for unit consistency check. The software automatically checked when the model was run and confirmed that all the units within the model were correct and consistent with no any unit error. Figure 16 has no any error notification which is usually on the lower most right-hand corner of the screen. This proves all the units in the model pass the Dimensional Consistency test.

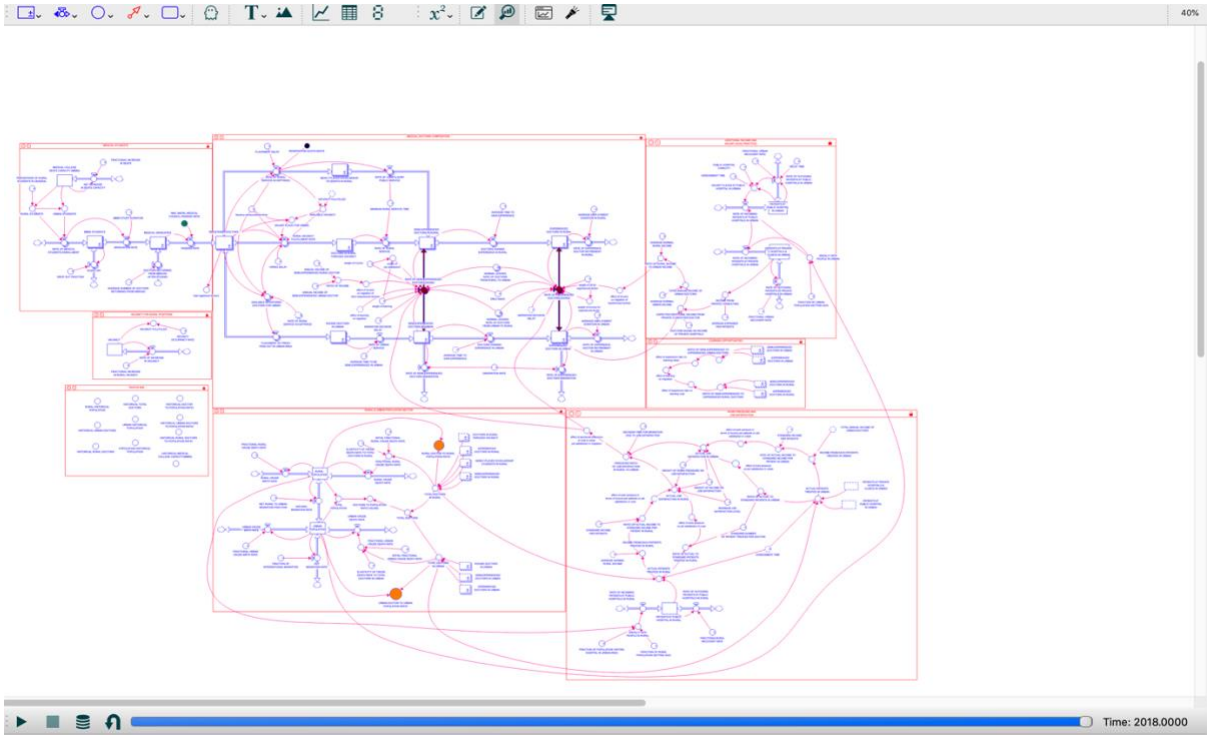

Figure 16. Unit Consistency test

4.3 Structure-Oriented Behavior Test

Structure-oriented behavior validation requires simulations, evaluating the validity of the model's structure indirectly, and is conducted by applying certain behavior tests to the behavior patterns generated by the model ((Barlas, 1996);(Forrester & Senge, 1980). These tests have been conducted with an assumption that all other variables except those under consideration are held constant *(ceteris paribus).*

The following structure-oriented behavior tests were selected in accordance with the purpose of the model in this research: the extreme- condition test and the behavior-sensitivity test.

Extreme condition test

The extreme-condition test tests the robustness of the model under extreme conditions of the parameters.(Sterman, 2000) demonstrates that model should behave in realistic fashion no matter what extreme values are set, how extreme the input or policies imposed on it be. It is conducted by assigning extreme values to selected parameters and comparing the model generated behavior of the real system under the extreme condition (Barlas, 1996) . For example, in real systems, stocks can never drop below zero (Sterman, 2000) so they must not

do so in modelled systems. Another way to test the model in the extreme-conditions test is to initiate the stocks with extreme values.

So, for our modelling purpose, extreme condition test was performed for various parameters. For example, RESERVATION QUOTA FRACTION is an exogenous here which is important for determining the NEWLY PLACED SCHOLARSHIP STUDENT IN RURAL, the lower rate mean decrease in RATE OF RURAL SERVICE ACCEPTANCE and NEWLY PLACED SCHOLARSHIP STUDENT IN RURAL which in turn increases the rural doctor ratio.

Extreme condition test ideally means changing the parameter value to both lowest and higher values. However, in case of VACANCY OCCUPANCY RATE which is an important exogenous variable which is used for determining the DOCTORS IN RURAL THROUGH VACANCY, lower rate mean decrease in VACANCY FULFILLED and DOCTORS IN RURAL THROUGH VACANCY. When we change the parameter value lowest and highest, the MIN function regulates the flow RURAL VACANCY FULFILLMENT RATE. Figure 17. explains when the VACANCY OCCUPANY RATE is set to zero, the stock of DOCTORS IN RURAL THROUGH VACANCY does not below zero and when vacancy is set to be 100 percent, it rises the stock of DOCTORS IN RURAL THROUGH VACANCY.

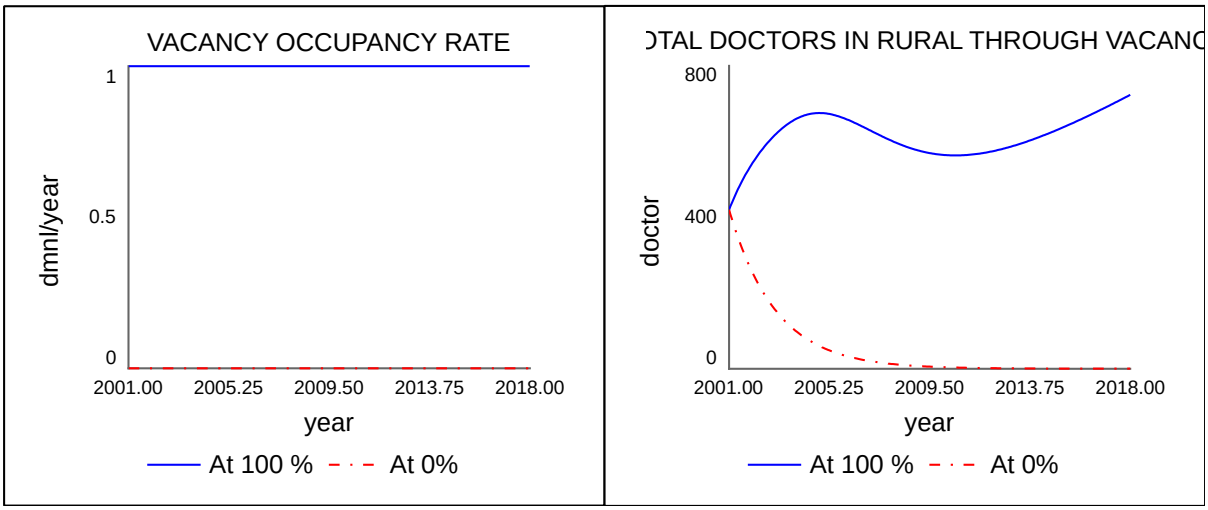

Figure 17. Extreme condition test: VACANCY OCCUPANCY RATE

Behaviour Sensitivity Test

The sensitivity analysis provided an evaluation of the impact of each factor. The aim of sensitivity analysis is to generate and compare behaviour pattern by changing the model parameters and assess the validity and reliability of the given model. In order to analyze parameter sensitivity, the sensitive parameters are identified and restricted to a reasonable range, to observe responses to variations in the model. (Yu et al., 2015). After the change in the sensitivity parameters, the outcome has showed changes in magnitude with different degree of sensitivity ranked either very sensitive, little sensitivity or no sensitivity but the patterns of behavior remain the same. Similarly, the graph function sensitivity tests were conducted by changing the shape and the slope of the graph.

For this modelling purpose various parameters were tested for sensitivity by using sensitivity features of stella. The following are the identified key sensitive parameters in the model:

- RESERVATION QUOTA SEATS is an exogenous variable that increase in reservation quota did increase the rural doctor ratio but such increase in rural doctor ratio decreases the urban doctor ratio.

Parameter	High value	Base run value	Low value	Tested variable
RESERVATION QUOTA SEATS	0.30	0.136	0	TOTAL DOCTORS IN RURAL, TOTAL DOCTORS IN URBAN

Table 3. Parameter values of RESERVATION QUOTA SEATS for sensitivity test

Figure 18. below demonstrate the TOTAL DOCTORS IN RURAL and TOTAL DOCTORS IN URBAN are both sensitive to the change in parameter value of reservation quota seats. Higher fraction of scholarship seats would result in higher NEWLY PLACED SCHOLARSHIP STUDENTS IN RURAL placement and consequently higher SEMI-EXPERIENCED DOCTORS IN RURAL resulting in higher TOTAL DOCTORS IN RURAL ratio and lower TOTAL DOCTORS IN URBAN. There is lower number of TOTAL DOCTORS IN URABN because, more the reservation quota seats, more students are placed

for compulsory rural bonding service, more doctors to practice medicine in rural, thus less TOTAL DOCTORS available for urban area.

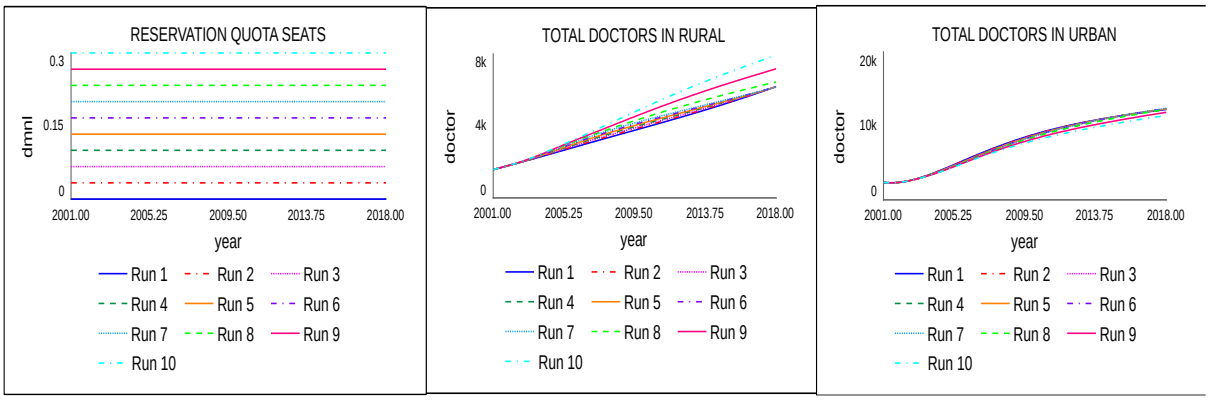

Figure 18. Sensitivity test: RESERVATION QUOTA SEATS

- FRACTIONAL INCREASE IN RURAL VACANCY is also another exogenous variable that increase in rural vacancy increases the rural doctors' population but decreases the urban doctors' population.

Parameter	High value	Base run value	Low value	Tested variable
FRACTIONAL INCREASE IN RURAL VACANCY	0.10	0.034	0	TOTAL DOCTORS IN RURAL, TOTAL DOCTORS IN URBAN

Table 4. Parameter values of FRACTIONAL INCREASE IN RURAL VACANCY for sensitivity test

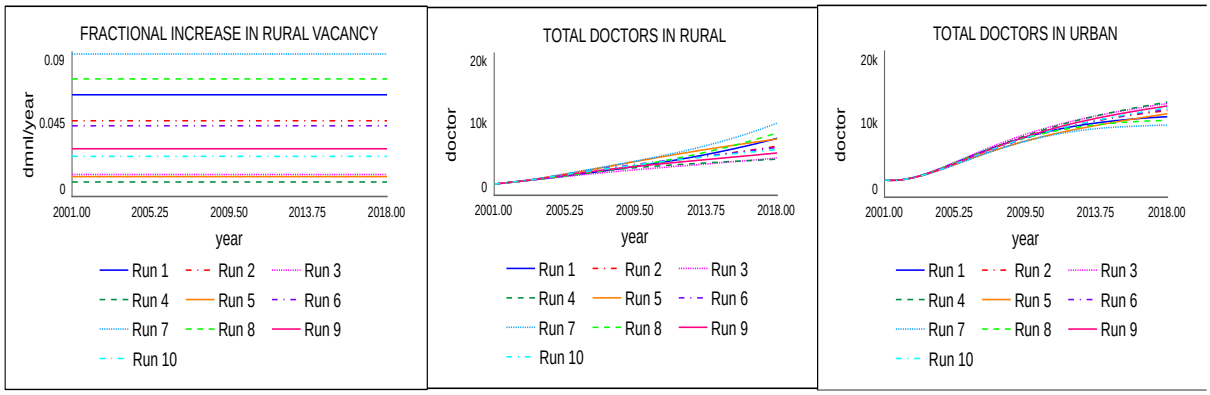

Figure 19. Sensitivity test: FRACTIONAL INCREASE IN RURAL VACANCY

From Figure 19. the TOTAL DOCTORS IN RURAL and TOTAL DOCTORS IN RURAL are changed with the change in estimated fractional increase in rural vacancy. When estimated fraction of rural vacancy is increased, the doctors' in rural through vacancy also increased due to availability of more vacancy placement only for rural positions. Increase in FRACTIONAL INCREASE IN RURAL VACANCY increased TOTAL DOCTORS IN RURAL which increases the stock of SEMI-EXPERIENCED DOCTORS IN RURAL which in turn increases the stock of TOTAL DOCTORS IN RURAL and decreases the TOTAL DOCTORS IN URBAN. The TOTAL DOCTORS IN URBAN IS DECREASED because the PLACEMENT OF FRESH PASS OUT IN URBAN AREA is the inflow to the ROOKIE DOCTORS which are the doctors available after their placement in rural through scholarship or rural vacancy positions.

Partial model testing

Partial model testing was conducted when analyzing the simulation runs while developing each sector. The modeler installed the effect switch for the decision variable for learning, work pressure and job satisfaction to check the effect of those variable to produce the desired behavior of reference mode. The behavior of each stock produced are compared with the historical data. Thus, each sector functioning as intended is confirmed through partial model testing.

4.4 Behavior Validity Test

After the model structure validity test, the other important and final validation step is to confirm whether the proposed structure reproduce and replicates the behavior of the real system.

According to (Barlas, 1996) it is most important to reproduce the patterns (trends, phases, frequencies, etc.) than to implement point- by-point prediction. The model generates and replicates the historical behavior of the real medical doctors' migrant stock in rural and Urban area of Nepal with some degree of accuracy both qualitatively and quantitatively together with historical behavior of other important variables.

The Figure 20. shows the simulated results compared to the results in the reference mode. The solid line represents real behavior from the data and dotted line represents model generated behavior. The comparison has been made of four variables namely DOCTORS TO POPULATION RATIO, RURAL DOCTOTRS TO RURAL POPULATION RATIO, URBAN DOCTORS TO URBAN POPULATION RATIO and POPULATION (in total, rural and urban). The model tends to replicate the behavior pattern which is close to real data trajectory however, the behavior of RURAL DOCTOR TO RURAL POPULATION undershoots actual data at the later time horizon whereas the behavior for URBAN DOCTOR TO URBAN POPULATION OVERSHOOTS in between the years and later it undershoots. It is mainly due to the assumptions made in 3.2. Moreover, other reason might be due to the delays in hiring, assessment, placement time which were calibrated in order to obtain the reference mode of behavior. These delays depend solely on the internal settings of the concerned government authority. In summary, the real behavior pattern of the period was closely reproduced by the model simulation, it can be claimed at this point that the model has passed the behavior-pattern prediction test.

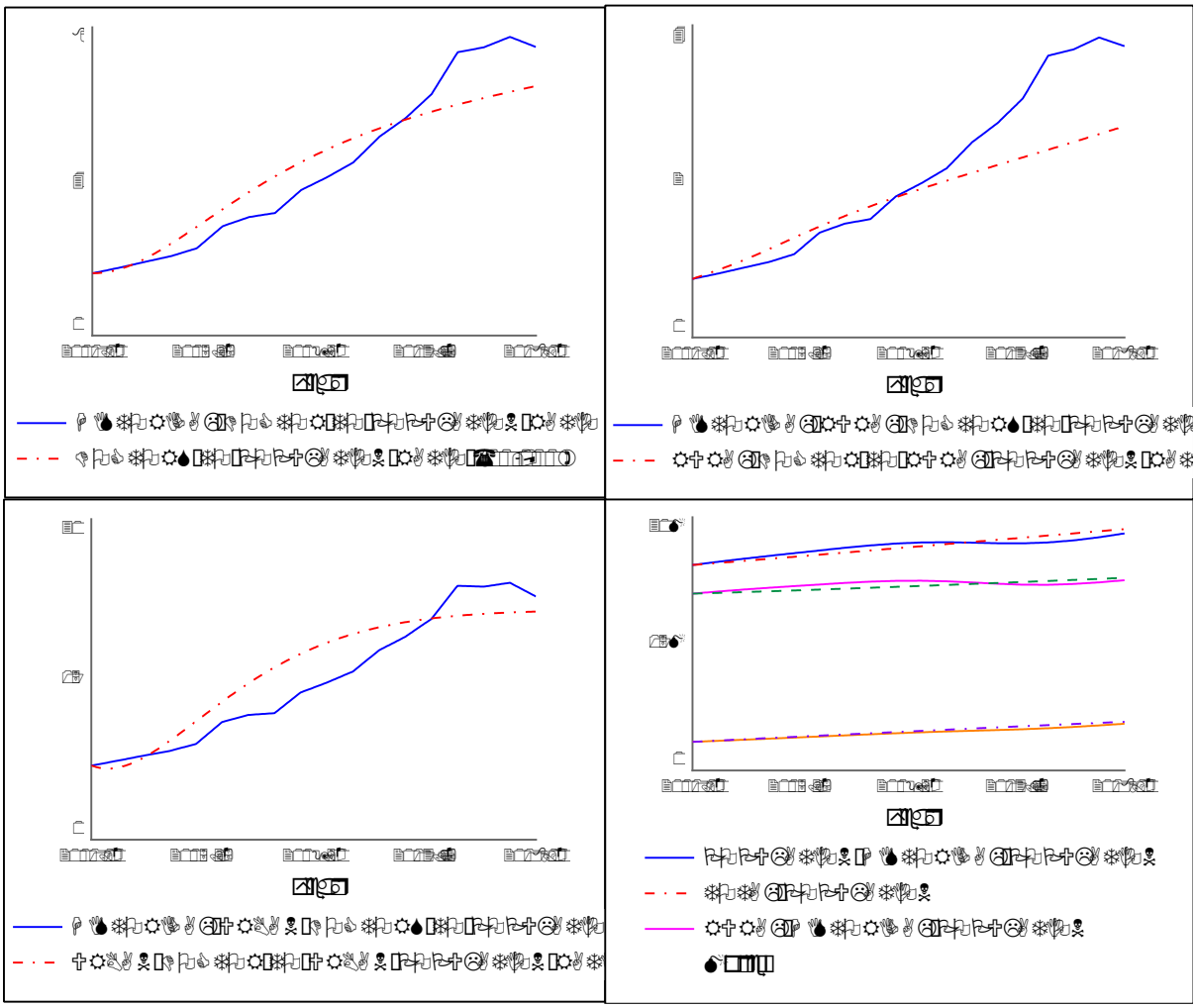

Figure 20. Behavior pattern test

Therefore, it can be concluded that after various tests on the model, the model is robust. The validation from the direct structure test and structure oriented behavior declares the structure of the model with the logic behind model generated behavior. The behavior pattern test are mainly confirmed by the model generated behavior produced by real data. The sensitivity analysis tests explained the important sensitive parameter that reveals the acceptable degree of uncertainty which are important consideration for model.

Chapter 5: Model Behavior

The previous chapter presented explanation to the model verification and validation. This chapter presents the simulation results of the developed model with confidence gathered from validated model. The behavior produced by model structure is classified as Ideal run and Base run which are explained in detail below:

5.1 Ideal Run

The ideal run exhibits the behavior under situation where the effect of learning, income and job satisfaction are not considered. In other words, it iterates the ideal situation assuming that doctor assigned to the rural area or urban areas stayed in their respective region without competing with their counter parts in another sector and without migrating. This situation is a hypothetical situation which is less likely to happen in reality.

In order to simulate the Ideal Run, the EFFECT SWITCH is made ineffective by assigning the value zero. When the effect switch is off, there is no interaction among the major reinforcing and balancing loop except the POPULATION MIGRATION LOOP. When these loops are inactive both URBAN DOCTOR TO URBAN POPULATION RATIO and RURAL DOCTOR TO RURAL POPULATION RATIO is improving as shown in Figure 21.

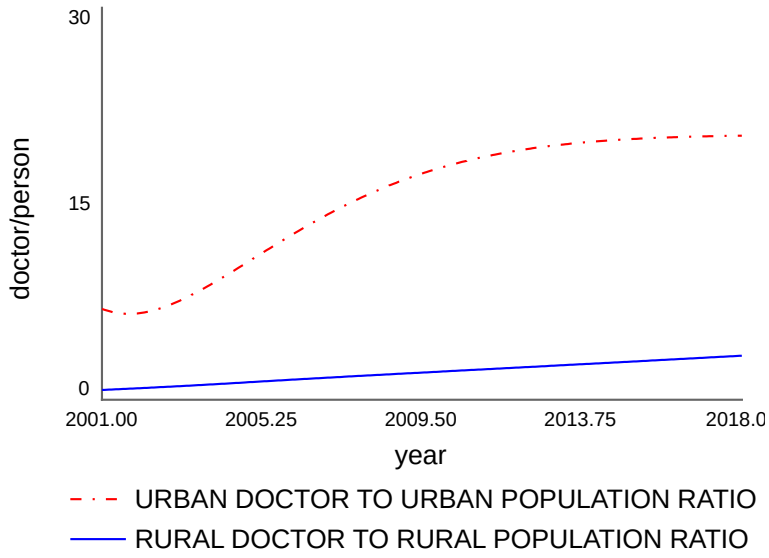

Figure 21. Ideal Run: TOTAL DOCTORS IN RURAL & TOTAL DOCTORS IN URBAN

Figure 21. demonstrates the dynamics of the system where the feedback loops described in the previous section are inactive, Ideal Run. In order to trace this behavior we look into the two major component that produces this behavior in Figure 22.

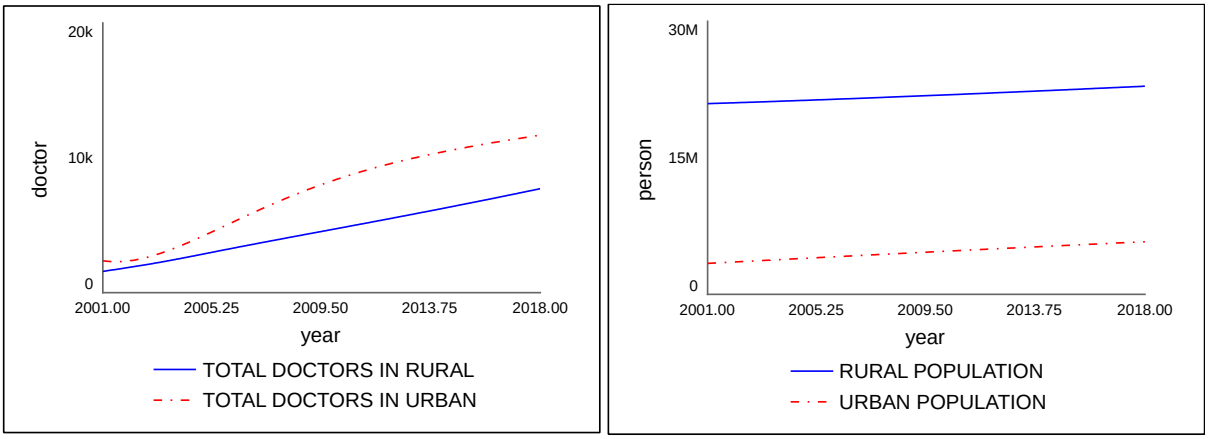

Figure 22.Ideal Run: TOTAL DOCTORS and POPULATION

Figure 22 justifies that increase in the doctor to population ratio in both urban and rural area shown in Figure 21. Although, the population in both rural and urban area has been increasing the ratio has been improving due the gradual increase in the TOTAL DOCTOR in both rural and urban area. A gradual increase of doctors in both urban and rural area is due to consideration that effect of learning, income and job satisfaction is zero and doctors do not migrate. Further, the increase in total doctors can be traced back to the increase in semi experienced and experienced doctors in these sectors shown in Figure 23.

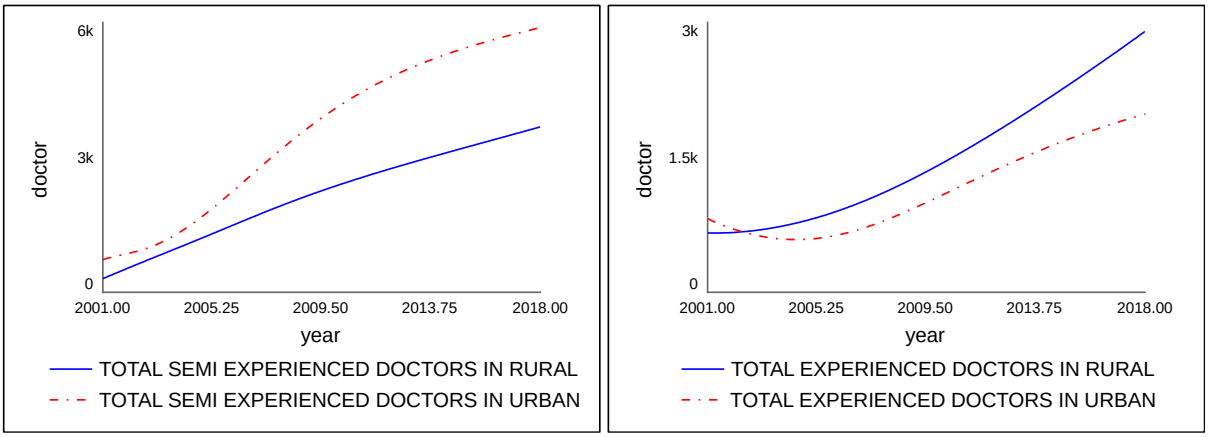

Figure 23. Ideal Run: TOTAL EXPERIENCED AND SEMI EXPERIENCED DOCTORS

The increase of total doctor in rural and urban area, under Ideal run, is due the increase in both semi-experienced and experienced doctors in both areas. Such increases in total doctors can be

traced back to the increases in REGISTERED DOCTORS after MEDICAL GRADUATES pass medical council examination. Such REGISTERED DOCTORS move along the aging chain to become SEMI-EXPEREINCED and EXPEREINCED DOCTORS for different area (urban or rural). However, it can be noted that the rate of increase in the doctors in urban area is slower than that of the rural which is mainly triggered due to the out migration of both semi-experienced and experienced doctors from rural and urban area driven by exogenous FRACTION OF URBAN DOCTOR MIGRATING ABROAD.

5.2 Base Run

Base run is to be considered as the actual representation of the existing situation of migration of the doctors from rural to urban. Base run is simulated by activating the effect switch, i.e., assigning value one to the EFFECT SWITCH. With this EFFECT SWITCH active, all the major loops, dormant during Ideal run, are activated resulting in interesting dynamics that caused the problematic behavior.

As shown in the ideal run, we start with the same key variable and trace back the effect of now active loops- learning loops (B1and B2), income loops (B3 and R4), retention loops (R2 and R3) and job satisfaction loops (R5, R6, R7 and R8). Figure 24 shows the behavior of key variable under explanation.

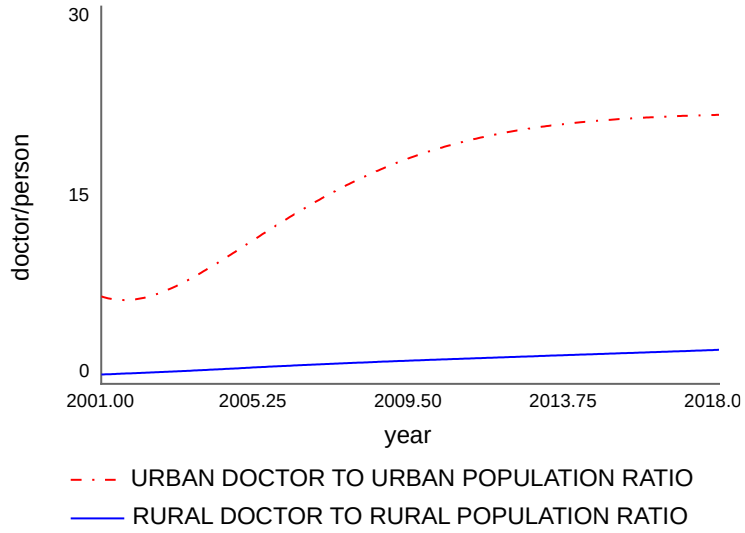

Figure 24. Base Run: TOTAL EXPERIENCED AND SEMI EXPERIENCED DOCTORS

As seen in above figure, similar to the Ideal run both URBAN DOCTOR TO URBAN POPULATION RATIO and RURAL DOCTOR TO RURAL POPULATION RATIO is increasing. Although the behavior looks similar, the actual value for the ratio have changes. In

terms of the numerical ratio, ratio of urban doctor to urban population has increased while ratio of rural doctor to rural population has decreased. Such difference in value is caused to the migration of doctor from rural to urban. Such migration of doctors is observed while analysing the sources of this behavior. Figure 25 depicts the behavior of sources that results in the behavior shown in Figure 24.

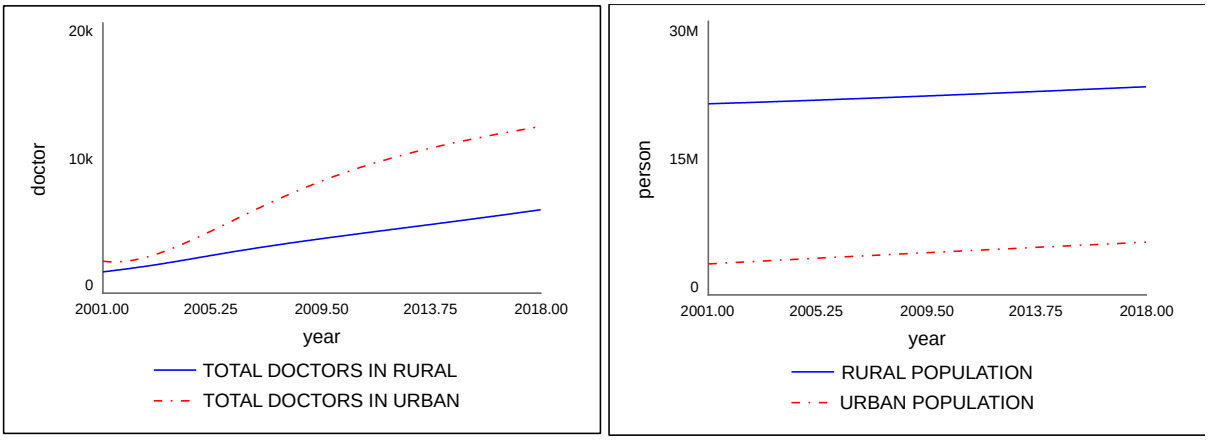

Figure 25. Base Run: TOTAL EXPERIENCED AND SEMI EXPERIENCED DOCTORS

Similar to the Ideal Run, the behavior of these TOTAL DOCTORS IN RURAL and TOTAL DOCTORS IN URBAN show as gradual increase in the number of doctors but the actual number value are significantly different. Likewise, the growth trend shown by the RURAL POPULATION and URBAN POPUALTION also similar. Figure 26 represents the breakdown of total doctor which is necessary to trace the effect of different loop and their impact on the rate of migration of doctors from rural to urban or vice versa.

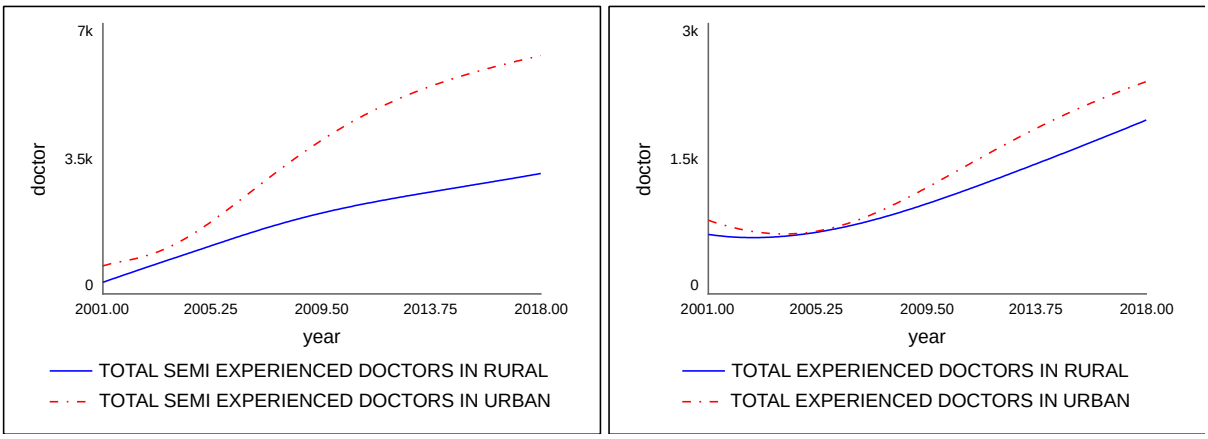

Figure 26. Base Run: TOTAL EXPERIENCED AND SEMI EXPERIENCED DOCTORS

Figure 26 exhibit the underlying cause of the problematic behaivor. The behavioral trends of over variables demonstrated in Figure 24 and 25 are similar to Ideal run, notably they differed in value. Similarly, Figure 26 also demonstrates a similar trend with the Ideal run. However, Figure 26 differs from Figure 23 noticeable in two ways: the gap between TOTAL SEMI EXPERIENCED DOCTORS IN RURAL and URBAN has widened and the TOTAL EXPERIENCED DOCTORS IN URBAN is higher in Base run.

Both these runs were performed with same initial values, thus total semi-experienced and experienced doctors in both rural and urban area were same. However, as urban doctors ahv the opportunity to earn additional income from private practice R4-URBAN PRIVATE INCOME LOOP is activated. R4 LOOP decreases PERCEIVED RATIO OF SATISFACTION IN RURUAL TO URBAN, as other loops are relative less dominant, which increases RATE OF EXPERIENCED DOCTORS LEAVING RURAL and decreases RATE OF EXPERIENCED DOCTORS LEAVING URBAN. Due to this active R4 LOOP, EXPERIENCED DOCTORS IN URBAN increases as first. PERCIEVED RATIO OF JOB SATISFACTION IN RURAL TO URBAN also effects migration of semi-experienced doctor; however, this effect is not very signification for semi-experienced doctor because of the lower WEIGHT OF JOB SATISFACTION, an exogenous input, assigned for semi-experienced doctors.

As EXPERIENCED DOCTORS IN URBAN increases RATIO OF SEMI EXPERIENCED TO EXPERIENCED URBAN DOCTOR decreases and RATE OF SEMI EXPERIENCED DOCTORS LEAVING FROM URBAN decreases. With experienced doctors increasing in urban the goal of the B2 balancing loop becomes higher than B1 strengthening R1 loop in favor of migration of SEMI-EXPERIENCED DOCTOR IN RURAL to SEMI-EXPERIENCED DOCTORS IN URBAN.

R1 and R4 loop moves doctors, both semi-experienced and experienced, for rural to urban. As a result, TOTAL DOCTOR IN RURAL decreases while RURAL POPULATION keeps on increasing mainly due to exogenous FRACTIONAL RURAL CRUDE BIRTH RATE. Increase in RURAL POPULATION and decrease in SEMI-EXPERIENCED DOCTOR IN RURAL and URBAN depletes the strength of R5 and R7 resulting in further strengthening of R6 and R8 LOOP which widens gap between semi-experience rural and urban doctors and increases the number of urban experienced doctors as shown by Figure 26. Behavior of both SEMI-EXPERIENCED DOCTORS IN URBAN and EXPERIENCED DOCTORS IN URBAN gradually flattens due to the effect of B2 which levels of the learning effect and slows down

the migration of semi experienced doctors from rural to urban. Moreover, B4 also play an important role to gradually decrease the strength of R4 and flattening the behavior of EXPERIENCE DOCTORS IN URBAN.

Chapter 6: Policy analysis

In the previous chapters we build the confidence in the system dynamic model developed to identify the cause of problematic behavior. In other word, we have developed an explanatory model that tends to replicate the reference mode behavior or problematic behavior with some degree of confidence arrived after performing several validation tests. Most often, we investigate the underlying system causing the problematic behavior to identify the cause agents and also aim to design improvements that may be helpful to alter the behavior. But before, current policies measures adopted by government of Nepal to address the issues are understood first.

6.1 Current policy and policy choice

The Government of Nepal has taken some measures to address problem of shortages of medical doctors pressures in the rural parts of Nepal due to the high uneven distribution of medical doctors because of internal migration from rural to urban parts of Nepal. The following are the major regulations adopted in retention and recruitment of medical workers in rural parts of Nepal:

1. In Nepal, the Ministry of Health and Population (MoHP) has implemented a compulsory two-year rural service for all the scholarship holders of the Ministry of Education as stated in (Sitaula & Magar, 2011) study. The other government institution Patan Academy of Health Sciences (PAHS) was established with the goal of addressing the health manpower imbalance in rural Nepal which started to enroll students having a rural rearing and rural schooling in MBBS as per (Sapkota & Amatya, 2015). But study of (Huntington et al., 2012) has an evidence of its effectiveness being short-term : “MOE programme may be effective in the short-term by forcing students into rural areas, but whether these students ultimately stay in rural areas beyond their 2-year obligation, or even stay in Nepal in the long term, should be tracked by the government”.
2. The Residential Training opportunities is the most important incentive for Bachelor of Medicine and Bachelor of Surgery (MBBS) graduates. In order to recruit the medical doctors in rural area, there is a provision of giving credit to those whose who work in

> rural Nepal. Such that on the basis of giving extra marks for work experience in remote rural areas they have higher chances for enrollment in a postgraduate institute in the country since 2002. The extra marks for enrollment in the Residential Training programme are given according to the remoteness of the areas posted as per the classification of the remote areas by the regulation of the Government. The highest extra marks are given up to maximum 20 and minimum 12 mark required to apply for study in the regulations.[6]

There are various policy measures adapted for retention and recruitment of medical doctors in rural. But despite these interventions and programmes no any significant changes has been seen on the internal migration behaviour of medical doctors which in turn address the long-term balance in the distribution of medical doctors in Nepal. Most policies concerning migration in Nepal and other developing countries are focused at regulating internal migration only. As mentioned earlier, 'brain drain" of skilled and qualified medical doctors to developed and high-income earning country like USA and UK also compound the problem of medical doctors' shortages in the country. Such policy has not affected the long-term retention thus, the following policy structure intervenes to through vacancy which has not been considered so far by policy makers.

The explanatory model has been developed to understand the cause of doctor's migration. As described in the Base run, intervention of several loop causes the problematic behavior and by shifting the strength of loops we can alter the problematic behavior to arrive at desired behavior. In that context, sensitivity analysis performed on the explanatory model identified some sensitive parameter that would lead the way for policy intervention.

In this chapter, we introduce, explain and examine the policy intervention point, accompanying structure and alteration caused by such policy intervention to result in desirable change in problematic behavior. As previously mentioned, the initialization of the model resembles the existing distribution of the doctors in urban and rural area. It was identified that due to the lower number of doctors in rural area, loops that reinforce the number of doctors in rural area-(R5 and R7) is less effective and loop that reinforces migration from rural to urban (R1) is strongly effective. Moreover, a key element that tends to increase the number of doctors to rural area, VACANCY, was exogenous to the model. Sensitivity analysis also identified that

6 https://pmjn.org.np/index.php/pmjn/article/view/45

the VACANCY is a possible policy intervention variable. Additionally, policy maker can practically intervene through vacancy while other behavioral elements are very subjective and clear intervention cannot be measured.

6.2 Policy Structure

This section describes the policy structure, which should be consider as a generic version of policy intervention. We have called this a generic version because it omits the policy implementation challenges while implementing this policy. More appropriately, this policy intervention can be thought as a desired wishful thinking that can be suggested in front of the policy maker to predetermine the impact of the suggested policy for achieving the desired result.

Based on the sensitivity analysis, VACANCY was identified as the sensitive parameter to the model. It is also assumed as an exogenous parameter in the explanatory model which can be considered quite realistic as policy maker tends to ignore the feedback perspective while making decision to announce vacancy. This desired wishful thinking link attempts to endogenize the VACANCY by connect it to the assumed goal of eliminating discrepancy in doctor to population ratio in rural and urban region of Nepal. Figure 27 presents the explanatory model with desired wishful thinking link.

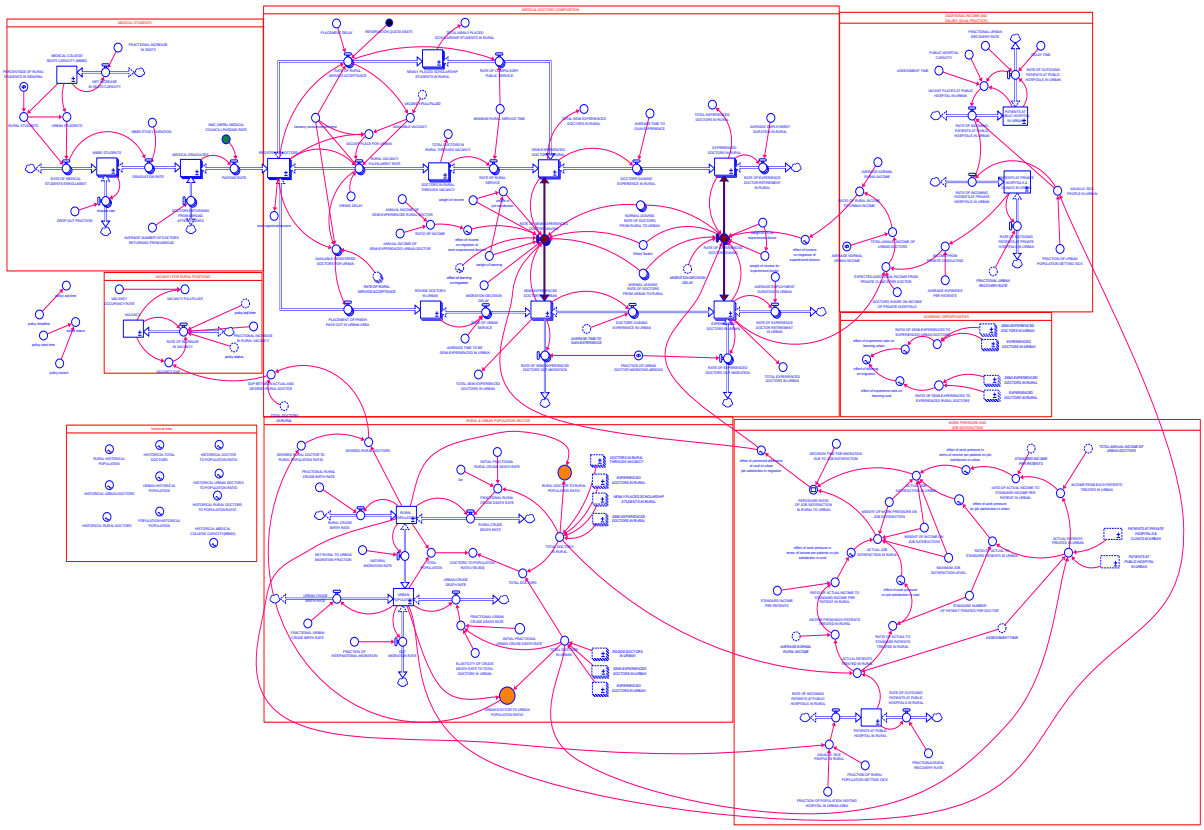

Figure 27. Explanatory model with policy link

In Figure 28, the dashed line represents the policy link, desired wishful link, that endogenizes the VACANCY in a way that tends to achieve the desired goal set for rural doctor anchored with the URBAN DOCTOR TO URBAN POPULATION RATIO. This link is a balancing loop that balances the vacancy in such a way that rural doctor to rural population tend to reach as close to the urban doctor to urban population.

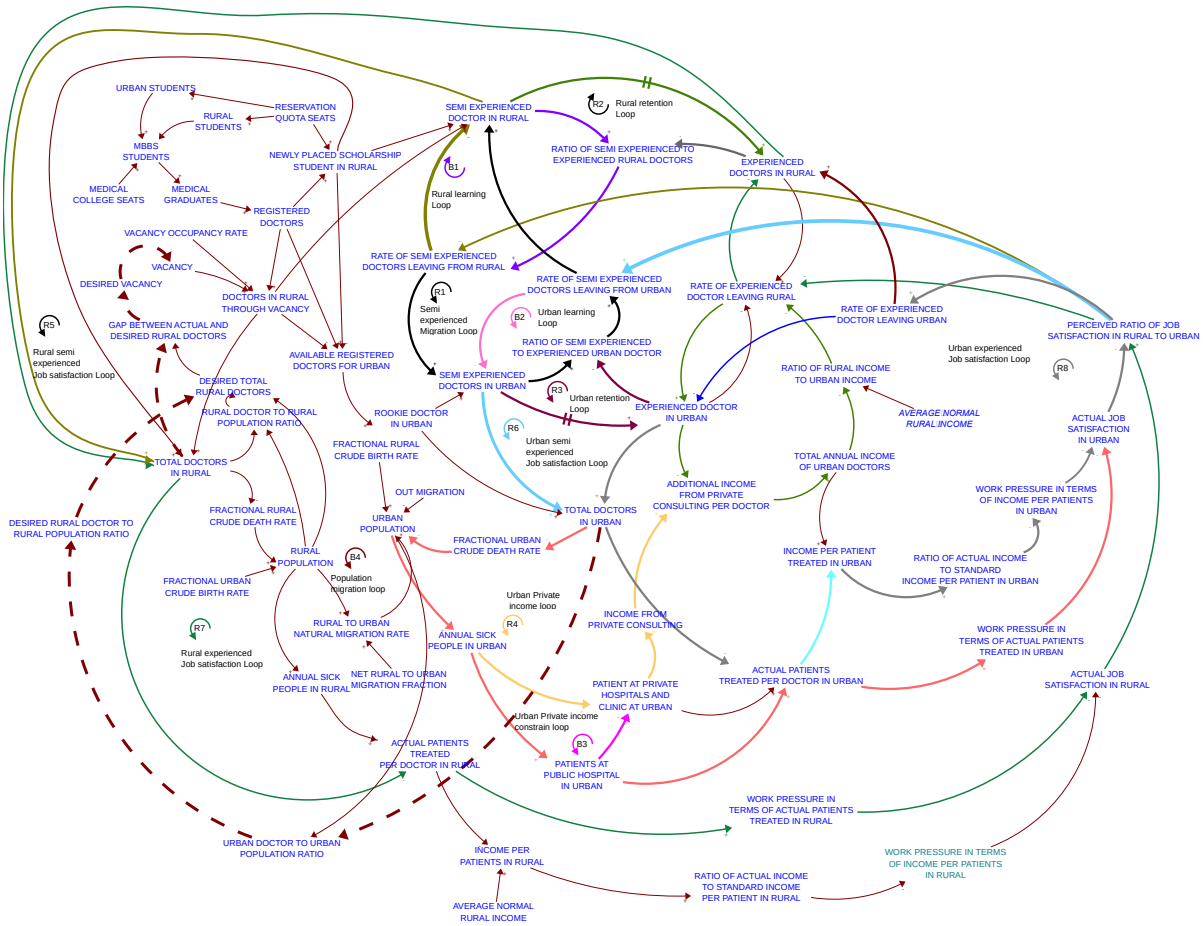

Figure 28. Policy CLD: Feedback perspective

During the analysis of the explanatory model, it was identified that the due to the less placement of doctors in rural area, loops that reinforce the number of doctors in rural area- (R5 and R7) is less effective and loop that reinforces migration from rural to urban (R1) is strongly effective. This resulted in higher deviation in the ratio of doctor to population in rural and urban area. With the goal to reduce this deviation, goal for the rural doctor to population ratio, DESIRED RURAL DOCTORS TO RURAL POPULATION RATIO, was set to match with that of URBAN DOCTOR TO URBAN POPULATION RATIO. This DESIRED RURAL DOCTORS TO RURAL POPULATION RATIO along with RURAL POPULATION determines the DESIRED TOTAL RURAL DOCTORS. A GAP BETWEEN ACTUAL AND DESIRED RURAL DOCTORS was determine which then set the goal for VACANCY, as DESIRED VACANCY.

In order to see the behavior of the model before and after policy, POLICY SWITCH is used. When the POLICY SWITCH is assigned with the value one the model runs as a policy model

with intervention, otherwise it represents the behavior of explanatory model. In addition to POLICY SWITCH, POLICY START TIME, POLICY STATUS and POLICY ADJUSTMENT TIME are added to the exploratory structure that suggests when policy kicks in, the activeness of policy and duration upon with desired goal is targeted to be achieved, respectively.

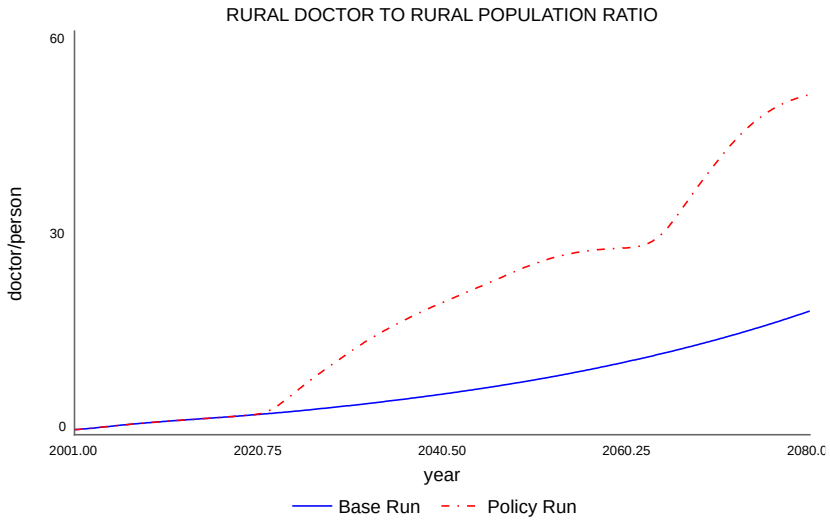

Figure 29. Policy Run: RURAL DOCTOR TO RURAL POPULATION RATIO

Figure 29 depicts that with policy intervention the model behavior has improved considerably as observed through the increase in RURAL DOCTOR TO RURAL POPULATION RATIO. This affirmative behavior is obtain with increased VACANCY that provided opportunities for doctor to work in rural area. With higher number of REGISTERED DOCTORS working in rural areas the workload for the doctor decreases resulting the job satisfaction loop (R5 and R7) further increasing the number of doctors in rural area. Moreover, higher job satisfaction increases the number of experienced doctors staying in rural area. This increases in EXPERIENCED DOCTORS IN RURAL decreases RATION OF SEMI-EXPERIENCED TO EXPERIENCED DOCTOR IN RURAL. Consequently, this strengthens the goal for RURAL LEARNING LOOP-B1 resulting in higher SEMI-EXPERIENCED DOCTOR IN RURAL and higher EXPERIENCED DOCTORS IN RURAL through R2-RURAL RETENTION LOOP.

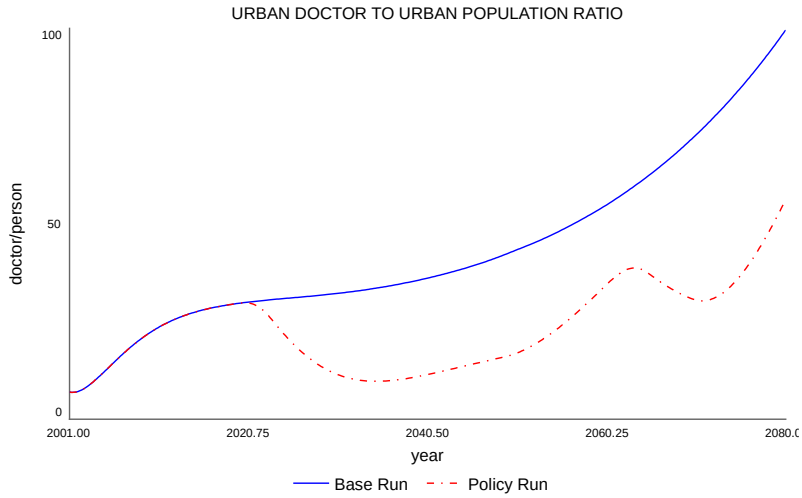

Figure 30. Policy Run: URBAN DOCTOR TO URBAN POPULATION RATIO

However, this desirable increase in the RURAL DOCTOR TO RURAL POPULATION RATIO comes at the cost of URBAN DOCTOR TO URBAN POPULATION RATIO shown in Figure 30. As R5 and R7 loop gains strength, R6 and R8 loops loses strength resulting in the migration of doctors from urban to rural. The comparison of policy run for urban and rural area is shown in Figure 31.

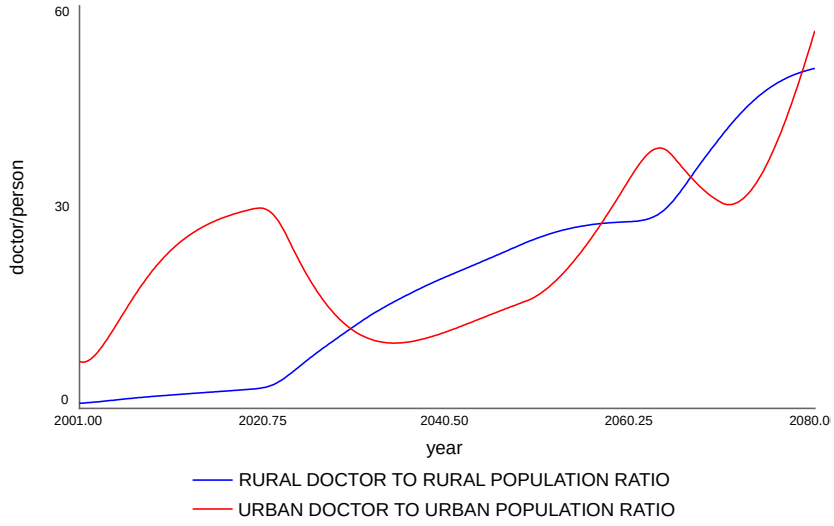

Figure 31. Comparative policy run

In Figure 31, it can be observed that as policy kicks in there is a substantial decrease in URBAN DOCTOR TO URBAN POPULATION RATIO as a trade-off which increase the RURAL DOCTOR TO RURAL POPULATION RATIO. It is practically impossible to constrain the trade off as the behavior elements tends to facilitate the migration of doctor where they assume,

they are better off. However, it should be mentioned here that this decrease in URBAN DOCTOR TO URBAN POPULATION RATIO is mainly caused due the constant migration of urban doctor out of country, which is reportedly twenty percent, significantly high. FRACTION OF URBAN DOCTOR MIGRATING ABROAD is an exogenous parameter to the model as it is beyond the model boundary.

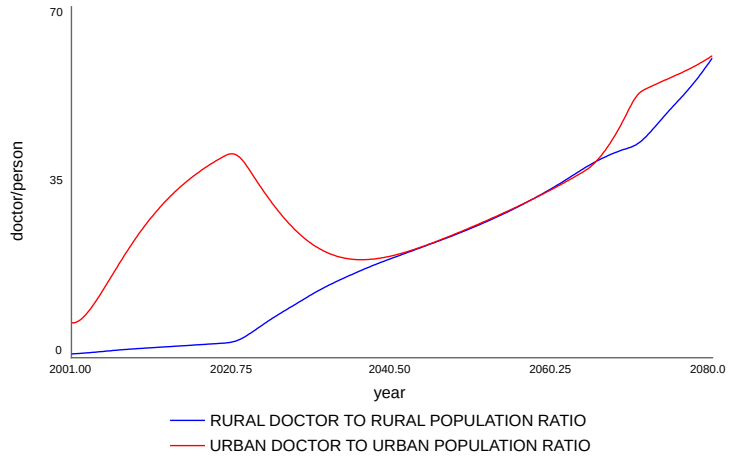

Figure 32. SCENARIO RUN WITH ACTIVE POLICY

An interesting behavior was identified, as shown in Figure 31, when the FRACTION OF URBAN DOCTOR MIGRATING ABROAD was tested for different value. It was noticed that when the FRACTION OF URBAN DOCTOR MIGRATING ABROAD is reduced to 0.03 despite of an initial drop in urban doctor to population ratio, the model shows an equal distribution of doctors in both rural and urban area.

Chapter 7: Conclusion & Limitations

Conclusion

In Nepal, an imbalance in the distribution of doctors in rural and urban area has been pointed out as a major public health issue. The uneven distribution of doctors is not the cause of lack of shortages of doctors as per MOHP in case of Nepal. There are sufficient number of doctors in Nepal produced every year. The root of the problem is that most of the doctors are based in urban areas and not serving the rural communities that need them most. This issue is further accelerated by the movement of doctors to overseas resulting to the wide discrepancy in the doctor to population ratio in rural versus urban location. The research objective and questions have been formulated "based on the above-mentioned problem description that make a basis to capture the current structure of the Nepalese medical doctors' movement using the system dynamic models.

A detailed description of model structure summarizes the process of medical students' enrolment for MBBS studies and composition of doctors in terms of rookies, semi-experienced, and experienced both in urban and rural. Moreover, the model looks on the feedback mechanism through CLD which explains how doctors move from rural to urban when the factors like learning opportunities, additional income and salary through dual practice and the work pressure affects job satisfaction; that in turn stimulates the migration flow. The balancing and reinforcing feedback loop, explains how B1 rural learning loop drives the strengths of R1 loop which accelerates the movement of semi experienced doctors from rural to urban and vice versa. Similarly, the other major determinants governing the migration of doctor is income. Which is captured by the R4 loop; urban private income loop comes to an effect where the income of urban becomes higher as such the experienced doctors move from rural to urban but later B4 loop constrain it. In addition, the loop R5 and R7 loops captures the work pressure and job satisfaction effects of semi-experienced and experienced doctors in rural. Similarly, other balancing and reinforcing feedback mechanisms loops also explains the dynamics on why doctors are not relocating their practice area to the rural area.

The base run and ideal run are performed in the model simulation that reflects the situation as it is and the situation where factors effects are inactive respectively. In the base run it is seen

that urban doctors' ratios are higher compared to rural doctors; ratio due to the interactions of feedback loops. But in ideal run, these effects are considered to be zero meaning that there is lower discrepancy in the doctors' ratio in rural vs. urban. From the simulation's result, it is understood that a greater ratio of experienced doctors in comparison to experienced doctors in rural plays a critical role in determining the learning opportunities effects for doctor to continue to work in rural. It is also found that vacancy openings in rural is sensitive to driving these effects. More vacant places, more doctors working, less work pressure and more satisfaction to stay in the urban.

Based on these results and sensitivity tests, a desired wishful thinking is developed to reduce this discrepancy to some extent. The proposed policy is based on the Vacancy which is assumed as an exogenous parameter in the explanatory model which can be considered quite realistic as policy maker tends to ignore the feedback perspective while making decision to announce vacancy. This desired wishful thinking link attempts to endogenize the VACANCY by connect it to the assumed goal of eliminating discrepancy in doctor to population ratio in rural and urban region of Nepal.

Limitation and Further work

The model built in this thesis held several assumptions. Thus, there are some limitations of the model and the modelling process which are mentioned below:

- Currently, the model works on several exogenous variable that only fits in for this modelling scope. The exogeneous parameter like medical college capacity, reservation quota and others are based on the government strategies. Thus, endogenizing these parameters has not been done which is an important limitation of this model.
- The model looks at the ratio of doctors to population ratio. It only considers the number of doctors for per population. It does not account any quality of health services provided to population.
- This model considers only three determinants for the doctors' migration. But there are other important factors like personal characteristics of the health worker, such as his or her place of origin (rural or urban), gender, age, have a significant impact on their employment decision. There are various empirical evidences that shows medical health personnel with rural background are most intent to work in rural areas than those from

urban or wealthier backgrounds. (Zimmerman et al., 2012), also found out that medical graduates with rural birthplace and graduation from rural high school were three to four times as likely to work in rural Nepal, compared with students raised in Kathmandu. This provides ground for further modelling considering the students' background.

- Different relative weights are assigned for the income, learning opportunities and work pressure and satisfaction based on the personal interview with doctors those are already practicing and has some experience. Thus, behavior of the model is limited to the weights assigned which might not be a realistic weight for a larger group of doctors.
- The shape of effects of learning opportunities, effects of additional income and salary through dual practice and effects of work pressure and job satisfaction in migration were not explained in any formal literature so, it has been developed based on the mainly on the advice and confirmation from limited insights from few doctors on interviewed. Therefore, these shapes cannot be generalized.
- The parameters value like income of doctors is not adjusted with the inflation rate. The income growth is not taken into account for this modelling. It is assumed to be constant which resemble another limitation of the model.
- The elasticity of Crude death rate to doctors are obtained from the historical data which shows that change in crude death based on change in number of doctors. There are numerous factors that affect the crude death rate (such as improvement in medicine technology, well equipped machinery, and so on) is beyond the scope of this thesis.

- This research is based on secondary data sources, extracted from different online websites and databases with the related academics and researchers' book, and other health-related journals. One of the greatest challenges in this research is that data on medical doctors which was collected from publicly available databases with gaps completed by data extrapolation. These data may be far from perfection. Since the census is only conducted once every decade, the data on the population statistics were extracted from World Bank report. After comparing data from various administrative bodies within the government, it was close to accurate. In fact, due to high numbers of undeclared migration either internal or external, Statistics Nepal has had to rely on estimations of other research work. These discrepancy between estimations only allow us for initial model testing and result replicating the historical behaviour.

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APPENDIX A

	Equation	Properties	Units	Documentation
policy_adj_time	MAX(1,(policy_deadline-TIME))		year	
policy_deadline	2070		years	
policy_start_time	2019		years	
policy_status	IF(policy_switch=1)AND(policy_start_time<TIME)THEN(1)ELSE(0)		Dimensionless	
policy_switch	0		dmnl	
total_registered_doctors	SUM(REGISTERED_DOCTORS)		doctor	It is the sum total of array of REGISTERED DOCTORS from rural background and urban background.
"ADDITIONAL_INCOME_AND_SALARY_(DUAL_PRACTICE)":				
ANUALLY_SICK_PEOPLE_IN_URBAN	FRACTION_OF_URBAN_POPULATION_GETTING_SICK*URBAN_POPULATION		persons/year	It is derived from the product between total urban population and fraction of urban population getting sick.
ASSESSMENT_TIME	1		year	It takes some time for doctor to assess the patients. It is assumed to be one here.
AVERAGE_EXPENSES_PER_PATIENTS	625		rupees/people	this is an exgoneous varibale which doctors at private hospitals and clinics charge for their consultation Rs 250-450 for each appointment, based on the practitioner's degree and experience. adapted from https://tkpo.st/37MP3ZH https://kathmandupost.com/national/2020/02/23/private-doctors-consultation-fees-likely-to-be-hiked \
AVERAGE_NORMAL_RURAL_INCOME	425600		rupees/doctor/year	Salaries for health workers are given under Section 9 of the Health Service Act, with basic salaries which range from NRs 11,290 to NRs 31,680 per month based on their qualification and number of experience in years. Additional allowances are given to provide a financial incentive for doctors at all levels who takes the posts in remote areas. So, the value here is the average salary

				plus allowances which is again further calibrated. The data is derived from report on Human resources for health in Nepal-The politics of access in remote areas available at:https://www.odi.org/sites/odi.org.uk/files/odi-assets/publications-opinion-files/8329.pdf
AVERAGE_NORMAL_URBAN_INCOME	380000		rupees/doctor/year	Salaries for health workers are given under Section 9 of the Health Service Act, with basic salaries which range from NRs 11,290 to NRs 31,680 per month based on their qualification and number of experience in years so, the value here is the average value which is again further calibrated. The data is derived from report on Human resources for health in Nepal-The politics of access in remote areas available at:https://www.odi.org/sites/odi.org.uk/files/odi-assets/publications-opinion-files/8329.pdf
DELAY_TIME	1		year	It takes sometime for patients to be recovered. SO, this delay captures the time frame of patients staying in hospital until they are fully recovered
DOCTORS_SHARE_ON_INCOME_OF_PRIVATE_HOSPITALS	0.15		dmnl/year	there is an agreement of doctors who are working on the private hospitals and clinics to charge the fee per patients. value is calibrated value. available: https://kathmandupost.com/national/2020/02/23/private-doctors-consultation-fees-likely-to-be-hiked
EXPECTED_ADDITIONAL_INCOME_FROM_PRIVATE_CLINICS_PER_DOCTOR	INCOME_FROM_PRIVATE_CONSULTING*DOCTORS_SHARE_ON_INCOME_OF_PRIVATE_HOSPITALS/EXPERIENCED_DOCTORS_IN_URBAN[urban_background]		rupees/doctor/year	it is the expected income of each doctor from their dual practice in private clinics and hospitals.
FRACTION_OF_URBAN_POPULATION_GETTING_SICK	0.60		dmnl/year	Out of total urban population only fraction of people get ill and are seeking for medical treatment. The value of this auxilliary variable is 77.4% from the study by Hotchkiss, Rous, Karmacharya & Sangraula (1998) on Household health expenditures in Nepal: Household health expenditures in Nepal:implications for health care financing reform. but for our modelling purpose, the calibrated value is used as 60%
FRACTIONAL_URBAN_RECOVERY_RATE	0.93		dmnl/year	The death rate of Nepal decreased from 8% to 6% from 2001 to 2018. so, taking the average of two years we get 7%. therefore we

				asssumed that death are either people being sick or through natural death, with or without seeking the health facilities. thus, the fractional recovery rate of either rural area or urban area is assumed calculated to be 93%. available from: https://www.macrotrends.net/countries/NPL/nepal/death-rate data source: United Nations - World Population Prospects
INCOME_FROM_PRIVATE_CONSULTING	PATIENTS_AT_PRIVATE_HOSPITALS_&_CLINICS_IN_URBAN*AVERAGE_EXPENSES_PER_PATIENTS		rupees	It is defined as total income the doctors earn from the private consultation of the patients who are visiting the private hospitals and clinics.
PATIENTS_AT_PRIVATE_HOSPITALS_&_CLINICS_IN_URBAN(t)	PATIENTS_AT_PRIVATE_HOSPITALS_&_CLINICS_IN_URBAN(t - dt) + (RATE_OF_INCOMING_PATIENTS_AT_PRIVATE_HOSPITALS_IN_URBAN - RATE_OF_OUTGOING_PATIENTS_AT_PRIVATE_HOSPITALS_IN_URBAN) * dt	INIT PATIENTS_AT_PRIVATE_HOSPITALS_&_CLINICS_IN_URBAN = 100000	people	It is a stock concept which is the total number of patients visiting the private hospitals and clinics in urban. The stock gets depleted with increase in the RATE OF OUTGOING PATIENTS AT PRIVATE HOSPITALS IN URBAN after their recovery. Due to the lack of information on the individual private clinics, the data is calibrated for capturing the problematic behavior.
PATIENTS_AT_PUBLIC_HOSPITAL_IN_URBAN(t)	PATIENTS_AT_PUBLIC_HOSPITAL_IN_URBAN(t - dt) + (RATE_OF_INCOMING_PATIENTS_AT_PUBLIC_HOSPITALS_IN_URBAN - RATE_OF_OUTGOING_PATIENTS_AT_PUBLIC_HOSPITALS_IN_URBAN) * dt	INIT PATIENTS_AT_PUBLIC_HOSPITAL_IN_URBAN = 422801	people	This is refers to total number of patients in the hospitals who are under medical treatment. It increases via increase in RATE OF INCOMING PATIENTS AT PUBLIC HOSPITALS IN URBAN and decreases with the RATE OF OUTGOING PATIENTS AT PUBLIC HOSPITALS IN URBAN after recovery. The initial value is adapted from https://kathmandupost.com/health/2019/07/29/patients-who-arrive-at-bir-hospital-are-forced-to-return-and-seek-private-care
PUBLIC_HOSPITAL_CAPACITY	1460000		people	It refers to the number of patients the government based public hospital in urban can handled. These accounts for the total number of patients either in need for emergency or OPD bed services the hospitals capable of handling.These are average values based on economic survey from the year 2000 to 2018 retrieved from https://mof.gov.np/en/archive-documents/economic-survey-21.html
RATE_OF_INCOMING_PATIENTS_AT_PRI	ANUALLY_SICK_PEOPLE_IN_URBAN-		persons/year	After the public hospitals in urban area are running in the full capacity, the other patients go to the other private hospitals

VATE_HOSPITALS_IN_URBAN	RATE_OF_INCOMING_PATIENTS_AT_PUBLIC_HOSPITALS_IN_URBAN			nearby for the treatment. So, it is the inflow rate at which that accumulates in the stock of PATIENTS AT PRIVATE HOSPITALS AND CLINICS IN URBAN.
RATE_OF_INCOMING_PATIENTS_AT_PUBLIC_HOSPITALS_IN_URBAN	MIN(ANUALLY_SICK_PEOPLE_IN_URBAN,VACANT_PLACES_AT_PUBLIC_HOSPITAL_IN_URBAN)		persons/year	It is defined as the inflow of patients coming to the hospitals for treatment. The hospitals are only able to take the patients only when they have the Vacant places or minimum sick patients in urban whichever is low. They cannot go beyond their capacity so MIN function is used in the formulation. It accumulates the STOCK OF PATIENTS AT PUBLIC HOSPITAL IN URBAN.
RATE_OF_OUTGOING_PATIENTS_AT_PRIVATE_HOSPITALS_IN_URBAN	PATIENTS_AT_PRIVATE_HOSPITALS_&_CLINICS_IN_URBAN*FRACTIONAL_URBAN_RECOVERY_RATE		persons/year	This rate of is outflow of patients from private hospitals and clinics in urban after being recovered. As, this flow increases, it depletes the number of sick people in private hospitals and clinics in Urban. Thus, the rate is based on the stock of PATIENTS AT PUBLIC HOSPITALS IN URBAN. More number of patients recovered, less would be the Patients at public hospitals.
RATE_OF_OUTGOING_PATIENTS_AT_PUBLIC_HOSPITALS_IN_URBAN	DELAY3(PATIENTS_AT_PUBLIC_HOSPITAL_IN_URBAN*FRACTIONAL_URBAN_RECOVERY_RATE, DELAY_TIME)		persons/year	This rate of is outflow of patients from public hospitals in urban after being recovered. As, this flow increases, it depletes the number of sick people in public hospitals in Urban. Thus, the rate is based on the stock of PATIENTS AT PUBLIC HOSPITALS IN URBAN. More number of patients recovered, less would be the Patients at public hospitals.
RATIO_OF_RURAL_INCOME_TO_URBAN_INCOME	AVERAGE_NORMAL_RURAL_INCOME/TOTAL_ANNUAL_INCOME_OF_URBAN_DOCTORS		dmnl	This ratio is calculated to analyse the relative INCOME EFFECTS ON MIGRATION. If the RATIO OF RURAL INCOME TO URBAN INCOME is lower than 1, the EXPERIENCED DOCTORS IN RURAL migrate from rural to urban location and if the ratio is higher than 1, the EXPERIENCED DOCTORS IN URBAN migrate from urban to rural location.
TOTAL_ANNUAL_INCOME_OF_URBAN_DOCTORS	AVERAGE_NORMAL_URBAN_INCOME+EXPECTED_ADDITIONAL_INCOME_FROM_PRIVATE_CLINICS_PER_DOCTOR		rupees/doctor/year	it is the total annual income of doctors from their basic salary and additional income from their dual practice in private hospitals and clinics.
VACANT_PLACES_AT_PUBLIC_HOSPITAL_IN_URBAN	((PUBLIC_HOSPITAL_CAPACITY-PATIENTS_AT_PUBLIC_HOSPITAL_IN_URBAN)/ASSESSMENT_TIME)+RATE_OF_OUTGOING_PATIENTS_AT_PUBLIC_HOSPITALS_IN_URBAN		persons/year	It represents the empty beds available for patients. It is calculated out of total CAPACITY of hospitals, the PATIENTS already under the medical attention are deducted and together with the number of recovered patients represented by RATE OF OUTGOING PATIENTS.

historical_data:				
HISTORICAL_DOCTOR_TO_POPULATION_RATIO	GRAPH(TIME) Points: (2001.00, 1.613333429), (2002.00, 1.753241687), (2003.00, 1.907030984), (2004.00, 2.055914582), (2005.00, 2.262230768), (2006.00, 2.83810455), (2007.00, 3.07096565), (2008.00, 3.179635811), (2009.00, 3.774057244), (2010.00, 4.108730202), (2011.00, 4.48981222), (2012.00, 5.159478269), (2013.00, 5.639973529), (2014.00, 6.26403545), (2015.00, 7.351833133), (2016.00, 7.477781687), (2017.00, 7.749157601), (2018.00, 7.486195225)		dmnl	
"HISTORICAL_MEDICAL_COLLEGE_CAPACITY(MBBS)"	GRAPH(TIME) Points: (2001.00, 902.0), (2002.00, 902.0), (2003.00, 972.0), (2004.00, 972.0), (2005.00, 972.0), (2006.00, 972.0), (2007.00, 1072.0), (2008.00, 1262.0), (2009.00, 1362.0), (2010.00, 1522.0), (2011.00, 1622.0), (2012.00, 1622.0), (2013.00, 1622.0), (2014.00, 1622.0), (2015.00, 1747.0), (2016.00, 1747.0), (2017.00, 1747.0), (2018.00, 1747.0)		doctor/year	
HISTORICAL_RURAL_DOCTORS	GRAPH(TIME) Points: (2001.00, 1571.2), (2002.00, 1734.0), (2003.00, 1913.2), (2004.00, 2090.4), (2005.00, 2329.6), (2006.00, 2959.2), (2007.00, 3240.8), (2008.00, 3391.6), (2009.00, 4058.4), (2010.00, 4439.6), (2011.00, 4856.4), (2012.00, 5570.0), (2013.00, 6072.4), (2014.00, 6741.6), (2015.00, 7944.4), (2016.00, 8154.8), (2017.00, 8565.2), (2018.00, 8413.2)		doctor	
HISTORICAL_RURAL_DOCTORS_TO_POPULATION_RATIO	GRAPH(TIME) Points: (2001.00, 0.749925482), (2002.00, 0.817743313), (2003.00, 0.892574931), (2004.00, 0.965682827), (2005.00, 1.066448592),		dmnl	

	(2006.00, 1.342877542), (2007.00, 1.458561909), (2008.00, 1.516007296), (2009.00, 1.806503707), (2010.00, 1.974591566), (2011.00, 2.166566705), (2012.00, 2.500227579), (2013.00, 2.744900086), (2014.00, 3.0623162), (2015.00, 3.610786946), (2016.00, 3.690400939), (2017.00, 3.8434575), (2018.00, 3.7320138)			
HISTORICAL_TOTAL_DOCTORS	GRAPH(TIME) Points: (2001.00, 3928.0), (2002.00, 4335.0), (2003.00, 4783.0), (2004.00, 5226.0), (2005.00, 5824.0), (2006.00, 7398.0), (2007.00, 8102.0), (2008.00, 8479.0), (2009.00, 10146.0), (2010.00, 11099.0), (2011.00, 12141.0), (2012.00, 13925.0), (2013.00, 15181.0), (2014.00, 16854.0), (2015.00, 19861.0), (2016.00, 20387.0), (2017.00, 21413.0), (2018.00, 21033.0), (2019.00, 21033.0), (2020.00, 21033.0)		doctor	
HISTORICAL_URBAN_DOCTORS	GRAPH(TIME) Points: (2001.00, 2356.8), (2002.00, 2601.0), (2003.00, 2869.8), (2004.00, 3135.6), (2005.00, 3494.4), (2006.00, 4438.8), (2007.00, 4861.2), (2008.00, 5087.4), (2009.00, 6087.6), (2010.00, 6659.4), (2011.00, 7284.6), (2012.00, 8355.0), (2013.00, 9108.6), (2014.00, 10112.4), (2015.00, 11916.6), (2016.00, 12232.2), (2017.00, 12847.8), (2018.00, 12619.8)		doctor	
HISTORICAL_URBAN_DOCTORS_TO_POPULATION_RATIO	GRAPH(TIME) Points: (2001.00, 6.940560846), (2002.00, 7.387254898), (2003.00, 7.870536827), (2004.00, 8.311762671), (2005.00, 8.959921888), (2006.00, 11.01321149), (2007.00, 11.67593586), (2008.00, 11.84589578), (2009.00, 13.77896081), (2010.00, 14.70204158), (2011.00, 15.74623415), (2012.00, 17.73173822), (2013.00,		dmnl	

	18.99435399), (2014.00, 20.67038318), (2015.00, 23.7705456), (2016.00, 23.68835527), (2017.00, 24.05062841), (2018.00, 22.76074542)			
POPULATION_HISTORICAL_POPULATION	GRAPH(TIME) Points: (2001.00, 24347106.0), (2002.00, 24725627.0), (2003.00, 25080872.0), (2004.00, 25419344.0), (2005.00, 25744500.0), (2006.00, 26066693.0), (2007.00, 26382581.0), (2008.00, 26666576.0), (2009.00, 26883535.0), (2010.00, 27013212.0), (2011.00, 27041437.0), (2012.00, 26989862.0), (2013.00, 26917906.0), (2014.00, 26906926.0), (2015.00, 27015031.0), (2016.00, 27261131.0), (2017.00, 27627124.0), (2018.00, 28087871.0)		person	
RURAL_HISTORICAL_POPULATION	GRAPH(TIME) Points: (2001.00, 20951415.0), (2002.00, 21204698.0), (2003.00, 21434615.0), (2004.00, 21646859.0), (2005.00, 21844466.0), (2006.00, 22036261.0), (2007.00, 22219146.0), (2008.00, 22371924.0), (2009.00, 22465495.0), (2010.00, 22483637.0), (2011.00, 22415188.0), (2012.00, 22277972.0), (2013.00, 22122481.0), (2014.00, 22014709.0), (2015.00, 22001852.0), (2016.00, 22097328.0), (2017.00, 22285143.0), (2018.00, 22543325.0)		person	
URBAN_HISTORICAL_POPULATION	GRAPH(TIME) Points: (2001.00, 3395691.0), (2002.00, 3520929.0), (2003.00, 3646257.0), (2004.00, 3772485.0), (2005.00, 3900034.0), (2006.00, 4030432.0), (2007.00, 4163435.0), (2008.00, 4294652.0), (2009.00, 4418040.0), (2010.00, 4529575.0), (2011.00, 4626249.0), (2012.00, 4711890.0), (2013.00,		person	

	4795425.0), (2014.00, 4892217.0), (2015.00, 5013179.0), (2016.00, 5163803.0), (2017.00, 5341981.0), (2018.00, 5544546.0)			
LEARNING_OPPORTUNITIES:				
effect_of_experience_ratio_on_learning_rural	GRAPH("RATIO_OF_SEMI-EXPERIENCED_TO_EXPERIENCED_RURAL_DOCTORS") Points: (0.500, 2.000), (0.650, 1.716), (0.800, 1.362), (0.950, 1.108), (1.000, 1.000), (1.250, 0.745), (1.400, 0.640), (1.550, 0.596), (1.700, 0.548), (1.850, 0.526979314943), (2.000, 0.500)		dmnl	The improvement in hiring and retention of experienced doctor in rural increases the chances for the semi-skilled doctors to continue to practice and serve the public in rural and thus reduces the learning gap. As the gap narrows the between the stock of SEMI-EXPERIENCED DOCTORS IN RURAL to EXPERIENCED DOCTORS IN RURAL, the higher learning opportunities for semi-experienced doctors in rural
effect_of_experience_ratio_on_learning_urban	GRAPH("RATIO_OF_SEMI-EXPERIENCED_TO_EXPERIENCED_URBAN_DOCTORS") Points: (0.500, 2.000), (0.650, 1.716), (0.800, 1.362), (0.950, 1.108), (1.000, 1.000), (1.250, 0.745), (1.400, 0.640), (1.550, 0.596), (1.700, 0.548), (1.850, 0.526979314943), (2.000, 0.500)		dmnl	The improvement in hiring and retention of experienced doctor in urban increases the chances for the semi-skilled doctors to continue to practice and serve the public in urban and thus reduces the learning gap. As the gap narrows the between the stock of SEMI-EXPERIENCED DOCTORS IN URBAN to EXPERIENCED DOCTORS IN URBAN, the higher learning opportunities for semi-experienced doctors in URBAN
effect_of_learning_on_migration	GRAPH(effect_of_experience_ratio_on_learning_rural//effect_of_experience_ratio_on_learning_urban) Points: (0.500, 1.000), (0.650, 0.986), (0.800, 0.908), (0.950, 0.786), (1.000, 0.750), (1.250, 0.606), (1.400, 0.480), (1.550, 0.353), (1.700, 0.178), (1.850, -0.076), (2.000, -0.500)		dmnl	This effect of learning on migration of semi-experienced doctors represent the tendency how semi-experienced doctors tend to move to and flow rural and urban sector depending on the ratio of semi-experienced doctor to urban doctors for both rural and urban sector. The y-axis range from -0.5 to 1 for x-axis value of 0.5 to 1.5 suggesting that should increase more than 100% to trigger the movement of doctor from urban to rural. Moreover, -0.5 in y-axis suggest that only half of the normal leaving rate would migrate for more than 100% increase in income. In the absence of literature, the shape of the graph was first estimated by the modeller based on the information derived from motivational theory and limited literature that studied income as determining factor for migration. Afterwards, the shape of the curve was validated through interview with the few doctors practicing in urban area.

"RATIO_OF_SEMI-EXPERIENCED_TO_EXPERIENCED_RURAL_DOCTORS"	SUM("SEMI-EXPERIENCED_DOCTORS_IN_RURAL")/SUM(EXPERIENCED_DOCTORS_IN_RURAL)		dmnl	It is the ratio to measure the learning of doctors in terms of staffing gap in rural setting. More experienced doctor means more guidance and sharing in the work pressure, and thus more learning opportunities in workplace.(Pilon & Herweg, 2001). if the ratio is lower than 1, the learning is more for semi-experienced doctors from experienced doctors in rural but if the ratio is higher than 1, the learning is not satisfactory for semi-experienced doctors.
"RATIO_OF_SEMI-EXPERIENCED_TO_EXPERIENCED_URBAN_DOCTORS"	SUM("SEMI-EXPERIENCED_DOCTORS_IN_URBAN")/SUM(EXPERIENCED_DOCTORS_IN_URBAN)		dmnl	It is the ratio to measure the learning of doctors in terms of staffing gap in urban setting. More experienced doctor means more guidance and sharing in the work pressure, and thus more learning opportunities in workplace.(Pilon & Herweg, 2001). if the ratio is lower than 1, the learning is more for semi-experienced doctors from experienced doctors in urban but if the ratio is higher, the learning is not satisfactory for semi-experienced doctors.
MEDICAL_DOCTORS_COMPOSITION:				
"ANNUAL_INCOME_OF_SEMI-EXPERIENCED_RURAL_DOCTOR"	336000		rupees/year	Salaries for health workers are given under Section 9 of the Health Service Act, with basic salaries which range from NRs 11,290 to NRs 31,680 per month based on their qualification and number of experience in years. Additional allowances are given to provide a financial incentive for doctors at all levels who takes the posts in remote areas. So, the value here is the average salary plus allowances which is again further calibrated. The data is derived from report on Human resources for health in Nepal-The politics of access in remote areas available at:https://www.odi.org/sites/odi.org.uk/files/odi-assets/publications-opinion-files/8329.pdf
"ANNUAL_INCOME_OF_SEMI-EXPERIENCED_URBAN_DOCTOR"	300000		rupees/year	Salaries for health workers are given under Section 9 of the Health Service Act, with basic salaries which range from NRs 11,290 to NRs 31,680 per month based on their qualification and number of experience in years so, the value here is the average value which is again further calibrated. The data is derived from report on Human resources for health in Nepal-The politics of access in remote areas available at:https://www.odi.org/sites/odi.org.uk/files/odi-assets/publications-opinion-files/8329.pdf

AVAILABLE_REGISTERED_DOCTORS_FOR_URBAN[background]	MAX(0, REGISTERED_DOCTORS/Vacancy_announcement_time-RATE_OF_RURAL_SERVICE_ACCEPTANCE-RURAL_VACANCY_FULFILLMENT_RATE)		doctor/year	These are the registered doctor available after rural service placement through reservation quota and vacancy openings. It is maximum of 0 or total registered doctors available after rate of rural service acceptance and rural vacancy fulfillment rate.
AVAILABLE_VACANCY	MAX(0, VACANCY_FULLFILLED-SUM(RATE_OF_RURAL_SERVICE_ACCEPTANCE))		doctor/year	It is actual vacancy available for rural postings after those doctors who are obliged to serve the rural area under their reservation rules.
AVERAGE_EMPLOYMENT_DURATION_IN_RURAL	18		year	In Nepal, there is provision of minimum 30 years for service to be provided and then get retired. so, the retirement age after being experienced doctor is 18 remaining years.
AVERAGE_EMPLOYMENT_DURATION_IN_URBAN	18		year	In Nepal, there is provision of minimum 30 years for service to be provided and then get retired. so, the retirement age after being experienced doctor is 18 remaining years.
"AVERAGE_TIME_TO_BE_SEMI-EXPERIENCED_IN_URBAN"	2		years	This is the average time to gain experience for rookies to be semi-experienced doctors in urban. For consistency purpose with rural rookies we assumed to be 2 years.
AVERAGE_TIME_TO_GAIN_EXPERIENCE	10		years	This is the average time to gain experience from semi-experience to be experienced doctor in rural.
DOCTORS_GAINING_EXPERIENCE_IN_RURAL[background]	MAX(0, "SEMI-EXPERIENCED_DOCTORS_IN_RURAL"/AVERAGE_TIME_TO_GAIN_EXPERIENCE)		doctor/year	
DOCTORS_GAINING_EXPERIENCE_IN_URBAN[background]	"SEMI-EXPERIENCED_DOCTORS_IN_URBAN"/AVERAGE_TIME_TO_GAIN_EXPERIENCE		doctor/year	
DOCTORS_IN_RURAL_THROUGH_VACANCY[rural_background](t)	DOCTORS_IN_RURAL_THROUGH_VACANCY[rural_background](t - dt) + (RURAL_VACANCY_FULFILLMENT_RATE[rural_background] -	INIT DOCTORS_IN_RURAL_THROUGH_VACAN	doctor	These are the freshly licensed doctors and placed under rural location through the vacancy openings for rural positions. It is stock that increases as the rate of RURAL VACANCY FULFILLMENT INCREASES and decreases with completion of RURAL SERVICE RATE.

	RATE_OF_RURAL_SERVICE[rural_background]) * dt	CY[rural_background] = 21		
DOCTORS_IN_RURAL_THROUGH_VACANCY[urban_background](t)	DOCTORS_IN_RURAL_THROUGH_VACANCY[urban_background](t - dt) + (RURAL_VACANCY_FULFILLMENT_RATE[urban_background] - RATE_OF_RURAL_SERVICE[urban_background]) * dt	INIT DOCTORS_IN_RURAL_THROUGH_VACANCY[urban_background] = 399		
effect_of_income_on_migration_of_experienced_doctors	GRAPH(RATIO_OF_RURAL_INCOME_TO_URBAN_INCOME) Points: (0.500, 1.000), (0.600, 0.983), (0.700, 0.974), (0.800, 0.948), (0.900, 0.873), (1.000, 0.700), (1.100, 0.397), (1.200, -0.050), (1.300, -0.255), (1.400, -0.408), (1.500, -0.500)		dmnl	This effect of income on migration of semi-experienced doctors represent the tendency how semi-experienced doctors tend to move to and flow rural and urban sector depending on the ratio of income. The y-axis range from -0.5 to 1 for x-axis value of 0.5 to 1.5 suggesting that rural income should increase more than 100% to trigger the movement of doctor from urban to rural. Moreover, -0.5 in y-axis suggest that only half of the normal leaving rate would migrate for more than 100% increase in income. It shows the effect of income on migration with ratio of RURAL INCOME TO URBAN INCOME. A wider income gap between the two locations increases the propensity to migrate thereby raising the NORMAL LEAVING RATE OF DOCTORS with rural background and urban background. In the absence of literature, the shape of the graph was first estimated by the modeller based on the information derived from motivational theory and limited literature that studied income as determining factor for migration. Afterwards, the shape of the curve was validated through interview with the few doctors practicing in urban area. AS per the report (Reducing Geographical Imbalances of Health Workers in Sub- Saharan Africa: A Labor Market Perspective on What Works, What Does Not, and Why) "the older doctors cite weak remuneration as their main reason for not considering rural positions. Older doctors face a higher opportunity cost for moving to rural areas, as the reputation they have built in the city o□en allows them to run a private practice"

effect_of_income_on_migration_of_semi_experienced_doctors	GRAPH(RATIO_OF_INCOME) Points: (0.500, 1.000), (0.600, 0.983), (0.700, 0.974), (0.800, 0.948), (0.900, 0.873), (1.000, 0.700), (1.100, 0.397), (1.200, -0.050), (1.300, -0.255), (1.400, -0.408), (1.500, -0.500)		dmnl	This effect of income on migration of semi-experienced doctors represent the tendency how semi-experienced doctors tend to move to and flow rural and urban sector depending on the ratio of income. The y-axis range from -0.5 to 1 for x-axis value of 0.5 to 1.5 suggesting that rural income should increase more than 100% to trigger the movement of doctor from urban to rural. Moreover, -0.5 in y-axis suggest that only half of the normal leaving rate would migrate for more than 100% increase in income. In the absence of literature, the shape of the graph was first estimated by the modeller based on the information derived from motivational theory and limited literature that studied income as determining factor for migration. Afterwards, the shape of the curve was validated through interview with the few doctors practicing in urban area.
Effect_Switch	1		dmnl	
EXPERIENCED_DOCTORS_IN_RURAL[rural_background](t)	EXPERIENCED_DOCTORS_IN_RURAL[rural_background](t - dt) + (DOCTORS_GAINING_EXPERIENCE_IN_RURAL[rural_background] - RATE_OF_EXPERIENCE_DOCTOR_RETIREMENT_IN_RURAL[rural_background] - RATE_OF_EXPERIENCED_DOCTOR_LEAVING[rural_background]) * dt	INIT EXPERIENCED_DOCTORS_IN_RURAL[rural_background] = 33	doctor	It is a stock of 'veteran' doctors which have developed relevant and wide competencies in the practice and study: this means that their expertise is the highest of the entire doctor's workforce in rural. They have already 10 years of experience in medicine practice. They provide coaching and training to SEMI-EXPERIENCED and ROOKIES in rural. The stock increases with the increase in inflow of DOCTORS GAINING EXPERIENCE IN RURAL and decreases with the RATE OF EXPERIENCED DOCTOR LEAVING for urban and RATE OF EXPERIENCE DOCTOR RETIREMENT IN RURAL.
EXPERIENCED_DOCTORS_IN_RURAL[urban_background](t)	EXPERIENCED_DOCTORS_IN_RURAL[urban_background](t - dt) + (DOCTORS_GAINING_EXPERIENCE_IN_RURAL[urban_background] - RATE_OF_EXPERIENCE_DOCTOR_RETIREMENT_IN_RURAL[urban_background] - RATE_OF_EXPERIENCED_DOCTOR_LEAVING[urban_background]) * dt	INIT EXPERIENCED_DOCTORS_IN_RURAL[urban_background] = 627		
EXPERIENCED_DOCTORS_IN_URBAN[rural_background](t)	EXPERIENCED_DOCTORS_IN_URBAN[rural_background](t - dt) + (DOCTORS_GAINING_EXPERIENCE_	INIT EXPERIENCED_DOCTORS_I	doctor	It is a stock of 'veteran' doctors which have developed relevant and wide competencies in the practice and study: this means that their expertise is the highest of the entire doctor's workforce in

	IN_URBAN[rural_background] + RATE_OF_EXPERIENCED_DOCTOR_LEAVING[rural_background] - RATE_OF_EXPERIENCE_DOCTOR_RETIREMENT_IN_URBAN[rural_background] - "RATE_OF-EXPERIENCED_DOCTORS_OUT_MIGRATION"[rural_background]) * dt	N_URBAN[rural_background] = 48		urban. They have already 10 years of experience in medicine practice. They provide coaching and training to SEMI-EXPERIENCED and ROOKIES in urban. The stock increases with the increase in inflow of DOCTORS GAINING EXPERIENCE IN URBAN and decreases with the RATE OF EXPERIENCED DOCTOR LEAVING for abroad and RATE OF EXPERIENCE DOCTOR RETIREMENT IN URBAN.
EXPERIENCED_DOCTORS_IN_URBAN[urban_background](t)	EXPERIENCED_DOCTORS_IN_URBAN[urban_background](t - dt) + (DOCTORS_GAINING_EXPERIENCE_IN_URBAN[urban_background] + RATE_OF_EXPERIENCED_DOCTOR_LEAVING[urban_background] - RATE_OF_EXPERIENCE_DOCTOR_RETIREMENT_IN_URBAN[urban_background] - "RATE_OF-EXPERIENCED_DOCTORS_OUT_MIGRATION"[urban_background]) * dt	INIT EXPERIENCED_DOCTORS_IN_URBAN[urban_background] = 770		
FRACTION_OF_URBAN_DOCTOR_MIGRATING_ABROAD	0.2		dmnl/year	The FRACTION OF URBAN DOCTOR MIGRATING ABROAD, exogenous parameter influences the RATE OF SEMI-EXPERIENCED DOCTORS OUT MIGRATION and RATE OF-EXPERIENCED DOCTORS OUT MIGRATION. The rate is 9% annually but it has been calibarted as 20% https://www.ilo.org/wcmsp5/groups/public/---asia/---ro-bangkok/---ilo-kathmandu/documents/publication/wcms_546805.pdf
GAP_BETWEEN_ACTUAL_AND_DESIRED_RURAL_DOCTOR	MAX(0, (DESIRED_RURAL_DOCTORS-TOTAL_DOCTORS_IN_RURAL))		doctor	
HIRING_DELAY	1.5		year	It represents the average number of days it takes for a candidate (doctor) to proceed from application process for an open position to accepting a position and placement to the respective location It takes more than 1.5 year in case of Nepal due to the combination of a lengthy legal selection process and administrative delays.

				Karki, K. B., Nepal, A., & Acharya, A. (2012). Human Resources for Health Management from Central to District Level in Nepal: A Report of Operational Research, May 2012 (Vol. 4). Society for Local Integrated Development Nepal.
MIGRATION_DECISION_DELAY	5		year	It is the time required for making decision whether to migrate or not
MINIMUM_RURAL_SERVICE_TIME	2		year	The Ministry of Health and Population (MOHP) has implemented a compulsory two year service contract in government health facilities for all the scholarship holders of the Ministry of Education, Sitaula & Magar (2011)
NEWLY_PLACED_SCHOLARSHIP_STUDENTS_IN_RURAL[rural_background](t)	NEWLY_PLACED_SCHOLARSHIP_STUDENTS_IN_RURAL[rural_background](t - dt) + (RATE_OF_RURAL_SERVICE_ACCEPTANCE[rural_background] - RATE_OF_COMPULSORY_PUBLIC_SERVICE[rural_background]) * dt	INIT NEWLY_PLACED_SCHOLARSHIP_STUDENTS_IN_RURAL[rural_background] = 10	doctor	These are the stocks of those students who have become doctors from the scholarship scheme or reservation quota alloted by the government and obliged to be placed and practice in rural area for atleast few years. This stock gets accumulated with increase in RATE OF RURAL SERVICE ACCEPTANCE and drained with RATE OF COMPULSORY PUBLIC SERVICE.
NEWLY_PLACED_SCHOLARSHIP_STUDENTS_IN_RURAL[urban_background](t)	NEWLY_PLACED_SCHOLARSHIP_STUDENTS_IN_RURAL[urban_background](t - dt) + (RATE_OF_RURAL_SERVICE_ACCEPTANCE[urban_background] - RATE_OF_COMPULSORY_PUBLIC_SERVICE[urban_background]) * dt	INIT NEWLY_PLACED_SCHOLARSHIP_STUDENTS_IN_RURAL[urban_background] = 178		
NORMAL_LEAVING_RATE_OF_DOCTORS_FROM_RURAL_TO_URBAN[rural_background]	0.02		dmnl/year	It is the natural migration rate of doctors from urban to rural. The values are assumed for calibration.
NORMAL_LEAVING_RATE_OF_DOCTORS_FROM_RURAL_TO_URBAN[urban_background]	0.1			
NORMAL_LEAVING_RATE_OF_DOCTORS	0.21		dmnl/year	

_FROM_URBAN_TO_RURAL[rural_background]				
NORMAL_LEAVING_RATE_OF_DOCTORS_FROM_URBAN_TO_RURAL[urban_background]	0.09			It is the natural migration rate of doctors from urban to rural. The values are assumed for calibration.
PLACEMENT_DELAY	1.5		year	This is the time required for the scholarship students who have owed to go to rural area through compulsory rural service bonding to go and get settled after being licensed from NMC. Government posting are usually announced every year and it requires six months to collect information of scholarship doctors, arrange legal contractual agreements and finally sanction the appointment. Thus, value of 1.5 year is used as PLACEMENT DELAY.
PLACEMENT_OF_FRESH_PASS_OUT_IN_URBAN_AREA[background]	MAX(0, AVAILABLE_REGISTERED_DOCTORS_FOR_URBAN)		doctor/year	It is a inflow rate at which the available doctors after rural postings and compulsory rural service employed themselves in the urban settings after adjusting the vacancy announcement time.
RATE_OF_COMPULSORY_PUBLIC_SERVICE[background]	DELAY3(RATE_OF_RURAL_SERVICE_ACCEPTANCE, MINIMUM_RURAL_SERVICE_TIME)		doctor/year	
RATE_OF_EXPERIENCE_DOCTOR_RETIREMENT_IN_RURAL[background]	MAX(0, EXPERIENCED_DOCTORS_IN_RURAL/AVERAGE_EMPLOYMENT_DURATION_IN_RURAL)		doctor/year	It is the retirement rate of doctors in rural after completing their 30 years of employment duration in rural settings.it decreases the stock of experience doctors in rural
RATE_OF_EXPERIENCE_DOCTOR_RETIREMENT_IN_URBAN[background]	MAX(0, EXPERIENCED_DOCTORS_IN_URBAN/AVERAGE_EMPLOYMENT_DURATION_IN_URBAN)		doctor/year	It is the retirement rate of doctors in urban after completing their 30 years of employment duration in urban settings. it decreases the stock of experience doctors in urban.
RATE_OF_EXPERIENCED_DOCTOR_LEAVING[rural_background]	IF Effect_Switch=1 THEN ((IF effect_of_perceived_difference_of_rural_to_urban_job_satisfaction_in_migration>0 THEN (MAX(0,SMTH3((EXPERIENCED_DOCTORS_IN_RUR		doctor/year	It is the bi-flow concept that guides the experienced doctors' movement from to and from rural versus urban. since, the decision of movement or continue to stay is affected by the important factors decision variable for the EXPERIENCED DOCTORS' LEAVING (movement or relocation) is income and

	AL[rural_background]*NORMAL_LEAVING_RATE_OF_DOCTORS_FROM_RURAL_TO_URBAN[rural_background]*effect_of_perceived_difference_of_rural_to_urban_job_satisfaction_in_migration*weight_of_JS_for_experienced_doctor*Effect_Switch),MIGRATION_DECISION_DELAY))) ELSE (SMTH3((EXPERIENCED_DOCTORS_IN_URBAN[rural_background]*NORMAL_LEAVING_RATE_OF_DOCTORS_FROM_URBAN_TO_RURAL[rural_background]*effect_of_perceived_difference_of_rural_to_urban_job_satisfaction_in_migration*weight_of_JS_for_experienced_doctor*Effect_Switch),MIGRATION_DECISION_DELAY))) + (IF effect_of_income_on_migration_of_experienced_doctors>0 THEN (MAX(0, SMTH3((EXPERIENCED_DOCTORS_IN_RURAL[rural_background]*NORMAL_LEAVING_RATE_OF_DOCTORS_FROM_RURAL_TO_URBAN[rural_background]*effect_of_income_on_migration_of_experienced_doctors*weight_of_income_for_experienced_doctor)*Effect_Switch,MIGRATION_DECISION_DELAY))) ELSE (SMTH3((EXPERIENCED_DOCTORS_IN_URBAN[rural_background]*NORMAL_LEAVING_RATE_OF_DOCTORS_FROM_URBAN_TO_RURAL[rural_background]*effect_of_income_on_migration_of_experienced_doctors*weight_of_income_for_experienced_doctor)*Effect_Switch,MIGRATION_DECISION_DELAY)))) ELSE 0			perceived job satisfaction. If the effect switch is on, all these decision variables control the movement. But if these are switch are turned off, the doctors movement is guided by the NORMAL LEAVING RATE OF DOCTORS FROM RURAL TO URBAN and FROM URBAN TO RURAL.
RATE_OF_EXPERIENCED_DOCTOR_LEAV	IF Effect_Switch=1 THEN ((IF effect_of_perceived_difference_of_rural_to_urban_job_satisfaction_in_migration>0			

ING[urban_background]	THEN (MAX(0,SMTH3((EXPERIENCED_DOCTORS_IN_RURAL[urban_background]*NORMAL_LEAVING_RATE_OF_DOCTORS_FROM_RURAL_TO_URBAN[urban_background]*effect_of_perceived_difference_of_rural_to_urban_job_satisfaction_in_migration*weight_of_JS_for_experienced_doctor*Effect_Switch),MIGRATION_DECISION_DELAY))) ELSE (SMTH3((EXPERIENCED_DOCTORS_IN_URBAN[urban_background]*NORMAL_LEAVING_RATE_OF_DOCTORS_FROM_URBAN_TO_RURAL[urban_background]*effect_of_perceived_difference_of_rural_to_urban_job_satisfaction_in_migration*weight_of_JS_for_experienced_doctor*Effect_Switch),MIGRATION_DECISION_DELAY))) + (IF effect_of_income_on_migration_of_experienced_doctors>0 THEN (MAX(0, SMTH3((EXPERIENCED_DOCTORS_IN_RURAL[urban_background]*NORMAL_LEAVING_RATE_OF_DOCTORS_FROM_RURAL_TO_URBAN[urban_background]*effect_of_income_on_migration_of_experienced_doctors*weight_of_income_for_experienced_doctor)*Effect_Switch,MIGRATION_DECISION_DELAY))) ELSE (SMTH3((EXPERIENCED_DOCTORS_IN_URBAN[urban_background]*NORMAL_LEAVING_RATE_OF_DOCTORS_FROM_URBAN_TO_RURAL[urban_background]*effect_of_income_on_migration_of_experienced_doctors*weight_of_income_for_experienced_doctor)*Effect_Switch,MIGRATION_DECISION_DELAY)))) ELSE 0			

RATE_OF_RURAL_SERVICE[background]	MAX(0,DOCTORS_IN_RURAL_THROUGH_VACANCY/ MINIMUM_RURAL_SERVICE_TIME)		doctor/year	
RATE_OF_RURAL_SERVICE_ACCEPTANCE[background]	DELAY3(REGISTERED_DOCTORS/Vacancy_announcement_time*RESERVATION_QUOTA_SEATS, PLACEMENT_DELAY)		doctor/year	The government started a 2-year bonding service program in 2004. This is an inflow of those students who are under the government scholarship, medical/dental doctors have to serve in the assigned rural places for 2 years as stated in Tamang, Poudel, Karki, & Gautam, (2020) article. It accumulates to increase the stock of NEWLY PLACED SCHOLARSHIP STUDENTS IN RURAL
"RATE_OF_SEMI-EXPERIENCED_DOCTOR_LEAVING"[rural_background]	IF Effect_Switch=1 THEN ((IF effect_of_learning_on_migration>0 THEN (MAX(0, SMTH3(("SEMI-EXPERIENCED_DOCTORS_IN_RURAL"[rural_background]*NORMAL_LEAVING_RATE_OF_DOCTORS_FROM_RURAL_TO_URBAN[rural_background]* effect_of_learning_on_migration*weight_of_learning)*Effect_Switch,MIGRATION_DECISION_DELAY))) ELSE (SMTH3(("SEMI-EXPERIENCED_DOCTORS_IN_URBAN"[rural_background]*NORMAL_LEAVING_RATE_OF_DOCTORS_FROM_URBAN_TO_RURAL[rural_background]* effect_of_learning_on_migration*weight_of_learning)*Effect_Switch,MIGRATION_DECISION_DELAY))) + (IF effect_of_perceived_difference_of_rural_to_urban_job_satisfaction_in_migration>0 THEN (MAX(0,SMTH3(("SEMI-EXPERIENCED_DOCTORS_IN_RURAL"[rural_background]*NORMAL_LEAVING_RATE_OF_DOCTORS_FROM_RURAL_TO_URBAN[rural_background]* effect_of_perceived_difference_of_rural_to_urban_job_satisfaction_in_migration*weight_of_job_satisfaction*Effect_Switch), MIGRATION_DECISION_DELAY))) ELSE (SMTH3(("SEMI-		doctor/year	It is the bi-flow concept that guides the semi-experienced doctors' movement from to and from rural versus urban. since, the decision of movement or continue to stay is affected by the important factors decision variable for the SEMI-EXPERIENCED DOCTORS' LEAVING (movement or relocation) is the learning opportunities in terms of guidance, supervision and mentoring to continuing education (professional courses and workshops) from the senior experienced doctors, income and perceived job satisfaction. If the effect switch is on, all these decision variables control the movement. But if these are switch are turned off, the doctors movement is guided by the NORMAL LEAVING RATE OF DOCTORS FROM RURAL TO URBAN and FROM URBAN TO RURAL.

	EXPERIENCED_DOCTORS_IN_RURAL"[rural_background]*NORMAL_LEAVING_RATE_OF_DOCTORS_FROM_URBAN_TO_RURAL[rural_background]*effect_of_perceived_difference_of_rural_to_urban_job_satisfaction_in_migration*weight_of_job_satisfaction*Effect_Switch), MIGRATION_DECISION_DELAY))) + (IF effect_of_income_on_migration_of_semi_experienced_doctors>0 THEN (MAX(0, SMTH3(("SEMI-EXPERIENCED_DOCTORS_IN_RURAL"[rural_background]*NORMAL_LEAVING_RATE_OF_DOCTORS_FROM_RURAL_TO_URBAN[rural_background]*effect_of_income_on_migration_of_semi_experienced_doctors*weight_of_income)*Effect_Switch,MIGRATION_DECISION_DELAY))) ELSE (SMTH3(("SEMI-EXPERIENCED_DOCTORS_IN_URBAN"[rural_background]*NORMAL_LEAVING_RATE_OF_DOCTORS_FROM_URBAN_TO_RURAL[rural_background]*effect_of_income_on_migration_of_semi_experienced_doctors*weight_of_income)*Effect_Switch,MIGRATION_DECISION_DELAY)))) ELSE 0			
"RATE_OF_SEMI-EXPERIENCED_DOCTOR_LEAVING"[urban_background]	IF Effect_Switch=1 THEN ((IF effect_of_learning_on_migration>0 THEN (MAX(0, SMTH3(("SEMI-EXPERIENCED_DOCTORS_IN_RURAL"[urban_background]*NORMAL_LEAVING_RATE_OF_DOCTORS_FROM_RURAL_TO_URBAN[urban_background]*effect_of_learning_on_migration*weight_of_learning)*Effect_Switch,MIGRATION_DECISION_DELAY))) ELSE (MAX(0,SMTH3(("SEMI-EXPERIENCED_DOCTORS_IN_URBAN"[urban_background]*NORMAL_LEA			

	VING_RATE_OF_DOCTORS_FROM_URBAN_TO_RURAL[urban_background]*effect_of_learning_on_migration*weight_of_learning)*Effect_Switch,MIGRATION_DECISION_DELAY)))) + (IF effect_of_perceived_difference_of_rural_to_urban_job_satisfaction_in_migration>0 THEN (MAX(0,SMTH3(("SEMI-EXPERIENCED_DOCTORS_IN_RURAL"[urban_background]*NORMAL_LEAVING_RATE_OF_DOCTORS_FROM_RURAL_TO_URBAN[urban_background]*effect_of_perceived_difference_of_rural_to_urban_job_satisfaction_in_migration*weight_of_job_satisfaction*Effect_Switch),MIGRATION_DECISION_DELAY))) ELSE (MAX(0,SMTH3(("SEMI-EXPERIENCED_DOCTORS_IN_URBAN"[urban_background]*NORMAL_LEAVING_RATE_OF_DOCTORS_FROM_URBAN_TO_RURAL[urban_background]*effect_of_perceived_difference_of_rural_to_urban_job_satisfaction_in_migration*weight_of_job_satisfaction*Effect_Switch),MIGRATION_DECISION_DELAY)))) + (IF effect_of_income_on_migration_of_semi_experienced_doctors>0 THEN (MAX(0,SMTH3(("SEMI-EXPERIENCED_DOCTORS_IN_RURAL"[urban_background]*NORMAL_LEAVING_RATE_OF_DOCTORS_FROM_RURAL_TO_URBAN[urban_background]*effect_of_income_on_migration_of_semi_experienced_doctors*weight_of_income)*Effect_Switch,MIGRATION_DECISION_DELAY))) ELSE (MAX(0,SMTH3(("SEMI-EXPERIENCED_DOCTORS_IN_URBAN"[urban_background]*NORMAL_LEAVING_RATE_OF_DOCTORS_FROM_URBAN_TO_RURAL[urban_background			

	]*effect_of_income_on_migration_of_semi_experienced_doctors*weight_of_income)*Effect_Switch,MIGRATION_DECISION_DELAY))))) ELSE 0			
"RATE_OF_SEMI-EXPERIENCED_DOCTORS_OUT_MIGRATION"[background]	"SEMI-EXPERIENCED_DOCTORS_IN_URBAN"*FRACTION_OF_URBAN_DOCTOR_MIGRATING_ABROAD		doctor/year	It is the rate of outflow of SEMI-EXPERIENCED DOCTORS from urban area to abroad.
RATE_OF_URBAN_SERVICE[background]	ROOKIE_DOCTORS_IN_URBAN/"AVERAGE_TIME_TO_BE_SEMI-EXPERIENCED_IN_URBAN"		doctor/year	
"RATE_OF-EXPERIENCED_DOCTORS_OUT_MIGRATION"[background]	MAX(0, EXPERIENCED_DOCTORS_IN_URBAN*FRACTION_OF_URBAN_DOCTOR_MIGRATING_ABROAD)		doctor/year	It is the rate of outflow of EXPERIENCED DOCTORS from urban area to abroad.
RATIO_OF_INCOME	"ANNUAL_INCOME_OF_SEMI-EXPERIENCED_RURAL_DOCTOR"/"ANNUAL_INCOME_OF_SEMI-EXPERIENCED_URBAN_DOCTOR"		DMNL	This ratio is calculated to analyse the relative INCOME EFFECTS ON MIGRATION OF SEMI-EXPERIENCED DOCTORS. If the RATIO OF RURAL INCOME TO URBAN INCOME is lower than 1, the SEMI-EXPERIENCED DOCTORS IN RURAL migrate from rural to urban location and if the ratio is higher than 1, the SEMI-EXPERIENCED DOCTORS IN URBAN migrate from urban to rural location.
REGISTERED_DOCTORS[rural_background](t)	REGISTERED_DOCTORS[rural_background](t - dt) + (PASSING_RATE[rural_background] - PLACEMENT_OF_FRESH_PASS_OUT_IN_URBAN_AREA[rural_background] - RURAL_VACANCY_FULFILLMENT_RATE[rural_background] - RATE_OF_RURAL_SERVICE_ACCEPTANCE[rural_background]) * dt	INIT REGISTERED_DOCTORS[rural_background] = 25	doctor	National Medical Council is official governmental body that distribute the eligibility certificate for those who passed their exam and are registered doctors (source: https://www.nmc.org.np/). The registered doctors are the cumulative number of doctors who passed the national exam every year in total. The total number of registered doctor increases with the increasing PASSING RATE and drained out with the outflow RATE OF RURAL SERVICE ACCEPTANCE, RURAL VACANCYFULFILLMENT RATE and PLACEMeNT OF FRESH PASS OUT IN URBAN AREA.
REGISTERED_DOCTORS[urban_background](t)	REGISTERED_DOCTORS[urban_background](t - dt) + (PASSING_RATE[urban_background] - PLACEMENT_OF_FRESH_PASS_OUT_IN_URBAN_AREA[urban_background]	INIT REGISTERED_DOCTORS[urban_background] = 407		

	- RURAL_VACANCY_FULFILLMENT_RATE[urban_background] - RATE_OF_RURAL_SERVICE_ACCEPTANCE[urban_background]) * dt			
RESERVATION_QUOTA_SEATS	0.136		dmnl	Nepal's Ministry of Education (MOE) has been providing a scholarship programme in which Nepali-owned private medical schools must reserve 10% of each class for the free education of students. The increase in reservation quota did increase the rural doctor ratio but such increase in rural doctor ratio decreases the urban doctor ratio. As per Nepal_MBBS_Scholarship_Study_Report.pdf 124 per year so out of 902 thus, 124/904= 13.6% so, the value here is taken as 13% available from: http://nsi.edu.np/images/category/Nepal_MBBS_Scholarship_Study_Report.pdf
ROOKIE_DOCTORS_IN_URBAN[rural_background](t)	ROOKIE_DOCTORS_IN_URBAN[rural_background](t - dt) + (PLACEMENT_OF_FRESH_PASS_OUT_IN_URBAN_AREA[rural_background] - RATE_OF_URBAN_SERVICE[rural_background]) * dt	INIT ROOKIE_DOCTORS_IN_URBAN[rural_background] = 55	doctor	These are the stock of those doctors at their first job experience, that are freshly graduates and registered without any experience as licensed doctors. They do not have skills and expertise in their practice; thus, they need training and know how sharing with more skilled doctors in order to improve their skills. This is stock accumulated by the rate of inflow of PLACEMENT OF FRESH PASS OUT IN URBAN AREA and drained by the outflow of RATE OF URBAN SERVICE.
ROOKIE_DOCTORS_IN_URBAN[urban_background](t)	ROOKIE_DOCTORS_IN_URBAN[urban_background](t - dt) + (PLACEMENT_OF_FRESH_PASS_OUT_IN_URBAN_AREA[urban_background] - RATE_OF_URBAN_SERVICE[urban_background]) * dt	INIT ROOKIE_DOCTORS_IN_URBAN[urban_background] = 762		
RURAL_VACANCY_FULFILLMENT_RATE[rural_background]	DELAY3(MIN(AVAILABLE_VACANCY, REGISTERED_DOCTORS[rural_background]/Vacancy_announcement_time), HIRING_DELAY)		doctor/year	This is an inflow rate at which RURAL VACANCY IS FULFILLED out of the total vacancy available.

RURAL_VACANCY_FULFILLMENT_RATE[urban_background]	DELAY3(MIN(REGISTERED_DOCTORS[urban_background]/ Vacancy_announcement_time, VACANT_PLACE_FOR_RURAL), HIRING_DELAY)			
"SEMI-EXPERIENCED_DOCTORS_IN_RURAL"[rural_background](t)	"SEMI-EXPERIENCED_DOCTORS_IN_RURAL"[rural_background](t - dt) + (RATE_OF_RURAL_SERVICE[rural_background] + RATE_OF_COMPULSORY_PUBLIC_SERVICE[rural_background] - DOCTORS_GAINING_EXPERIENCE_IN_RURAL[rural_background] - "RATE_OF_SEMI-EXPERIENCED_DOCTOR_LEAVING"[rural_background]) * dt	INIT "SEMI-EXPERIENCED_DOCTORS_IN_RURAL"[rural_background] = 16	doctor	It is a stock of those with some years of experience in the practice in rural location.They have achieved a certain 2 years of experience in their job career and are ready to provide training to NEWLY PLACED SCHOLARSHIP STUDENTS IN RURAL and DOCTORS IN RURAL THROUGH VACANCY. The stock increases with the increase in inflow of RATE OF COMPULSORY PUBLIC SERVICE and RATE OF RURAL SERVICE and decreases with the RATE OF SEMI-EXPERIENCED DOCTOR LEAVING for urban and DOCTORS GAINING EXPERIENCE IN RURAL.
"SEMI-EXPERIENCED_DOCTORS_IN_RURAL"[urban_background](t)	"SEMI-EXPERIENCED_DOCTORS_IN_RURAL"[urban_background](t - dt) + (RATE_OF_RURAL_SERVICE[urban_background] + RATE_OF_COMPULSORY_PUBLIC_SERVICE[urban_background] - DOCTORS_GAINING_EXPERIENCE_IN_RURAL[urban_background] - "RATE_OF_SEMI-EXPERIENCED_DOCTOR_LEAVING"[urban_background]) * dt	INIT "SEMI-EXPERIENCED_DOCTORS_IN_RURAL"[urban_background] = 288		
"SEMI-EXPERIENCED_DOCTORS_IN_URBAN"[rural_background](t)	"SEMI-EXPERIENCED_DOCTORS_IN_URBAN"[rural_background](t - dt) + (RATE_OF_URBAN_SERVICE[rural_background] + "RATE_OF_SEMI-EXPERIENCED_DOCTOR_LEAVING"[rural_background] - DOCTORS_GAINING_EXPERIENCE_IN_URBAN[rural_background] - "RATE_OF_SEMI-	INIT "SEMI-EXPERIENCED_DOCTORS_IN_URBAN"[rural_background] = 46	doctor	It is a stock of those with some years of experience in the practice in rural location.They have achieved a certain 2 years of experience in their job career and are ready to provide training to ROOKIE DOCTORS IN URBAN. The stock increases with the increase in inflow of RATE OF URBAN SERVICE and decreases with the RATE OF SEMI-EXPERIENCED DOCTOR LEAVING for rural or abroad and DOCTORS GAINING EXPERIENCE IN URBAN.

	EXPERIENCED_DOCTORS_OUT_MIGRATION"[rural_background]) * dt			
"SEMI-EXPERIENCED_DOCTORS_IN_URBAN"[urban_background](t)	"SEMI-EXPERIENCED_DOCTORS_IN_URBAN"[urban_background](t - dt) + (RATE_OF_URBAN_SERVICE[urban_background] + "RATE_OF_SEMI-EXPERIENCED_DOCTOR_LEAVING"[urban_background] - DOCTORS_GAINING_EXPERIENCE_IN_URBAN[urban_background] - "RATE_OF_SEMI-EXPERIENCED_DOCTORS_OUT_MIGRATION"[urban_background]) * dt	INIT "SEMI-EXPERIENCED_DOCTORS_IN_URBAN"[urban_background] = 680		
TOTAL_DOCTORS_IN_RURAL_THROUGH_VACANCY	SUM(DOCTORS_IN_RURAL_THROUGH_VACANCY)		doctor	It is the sum total of array of DOCTORS IN RURAL THROUGH VACANCY openings for rural positions irrespective of their background
TOTAL_EXPERIENCED_DOCTORS_IN_RURAL	SUM(EXPERIENCED_DOCTORS_IN_RURAL)		doctor	It is the sum total of array of EXPERIENCED DOCTORS in RURAL from rural background and urban background.
TOTAL_EXPERIENCED_DOCTORS_IN_URBAN	SUM(EXPERIENCED_DOCTORS_IN_URBAN)		doctor	It is the sum total of array of EXPERIENCED DOCTORS in URBAN from rural background and urban background.
TOTAL_NEWLY_PLACED_SCHOLARSHIP_STUDENTS_IN_RURAL	SUM(NEWLY_PLACED_SCHOLARSHIP_STUDENTS_IN_RURAL)		doctor	It is the sum total of array of NEWLY PLACED SCHOLARSHIP STUDENTS IN RURAL.
TOTAL_SEMI_EXPERIENCED_DOCTORS_IN_RURAL	SUM("SEMI-EXPERIENCED_DOCTORS_IN_RURAL")		doctor	It is the sum total of array of SEMI-EXPERIENCED DOCTORS in rural from rural background and urban background.
TOTAL_SEMI_EXPERIENCED_DOCTORS_IN_URBAN	SUM("SEMI-EXPERIENCED_DOCTORS_IN_URBAN")		doctor	It is the sum total of array of SEMI-EXPERIENCED DOCTORS in urban from rural background and urban background.
Vacancy_announcement_time	1		year	it is the time taken by PSC for vacancy announcement. it usually takes 1 year

VACANT_PLACE_FOR_RURAL	MAX(0, AVAILABLE_VACANCY-REGISTERED_DOCTORS[rural_background]/Vacancy_announcement_time)		doctor/year	It is the total vacancy available for rural background each year
weight_of_income	0.3		dmnl	There are several determinants of job satisfaction such as pay, work motivation,workload, integration as stated by Agho, A.O., Price , J.L, & Mueller ,C.W. (1993) in Determinants of Employee Job Satisfaction : An Empirical Test of Causal Model. Human Relations, 46 (8): 1007-1027. So, we have assigned the weight as 30% based on the response from few doctors's interview.
weight_of_income_for_experienced_doctor	1-weight_of_JS_for_experienced_doctor		dmnl	There are several determinants of job satisfaction such as pay, work motivation,workload, integration as stated by Agho, A.O., Price , J.L, & Mueller ,C.W. (1993) in Determinants of Employee Job Satisfaction : An Empirical Test of Causal Model. Human Relations, 46 (8): 1007-1027. So, we have assigned the weight as 40% based on the response from few doctors's interview.
weight_of_job_satisfaction	1-weight_of_income-weight_of_learning		dmnl	There are several determinants of job satisfaction such as pay, work motivation,workload, integration as stated by Agho, A.O., Price , J.L, & Mueller ,C.W. (1993) in Determinants of Employee Job Satisfaction : An Empirical Test of Causal Model. Human Relations, 46 (8): 1007-1027. So, we have assigned the weight as 100% based on the response from few doctors's interview.
weight_of_JS_for_experienced_doctor	0.6		dmnl	There are several determinants of job satisfaction such as pay, work motivation,workload, integration as stated by Agho, A.O., Price , J.L, & Mueller ,C.W. (1993) in Determinants of Employee Job Satisfaction : An Empirical Test of Causal Model. Human Relations, 46 (8): 1007-1027. So, we have assigned the weight as 60% based on the response from few doctors's interview.
weight_of_learning	0.5		dmnl	There are several determinants of job satisfaction such as pay, work motivation,workload, integration as stated by Agho, A.O., Price , J.L, & Mueller ,C.W. (1993) in Determinants of Employee Job Satisfaction : An Empirical Test of Causal Model. Human Relations, 46 (8): 1007-1027.

				So, we have assigned the weight as 50% based on the response from few doctors's interview.
MEDICAL_STUDENTS:				
AVERAGE_NUMBER_OF_DOCTORS_RETURNING_FROM_ABROAD	607		doctor/year	This value is estimated on the basis of report by ILO on migration of health workers from Nepal It is the average of 6 years from 2008 to 2013. https://www.ilo.org/wcmsp5/groups/public/---asia/---ro-bangkok/---ilo-kathmandu/documents/publication/wcms_546805.pdf
DOCTORS_RETURNING_FROM_ABROAD_AFTER_STUDIES[background]	AVERAGE_NUMBER_OF_DOCTORS_RETURNING_FROM_ABROAD		doctor/year	This is the rate of flow of students who returned from abroad after finishing their studies. Dozens of students go to foreign countries for the purpose of MBBS studies due to the limited number of medical seats availability.
DROP_OUT_FRACTION	0.054		dmnl/year	Every year in medical studies, certain percentage of students leave medical school before finishing their study due to various reasons like socio-economic, vast and overloaded curriculum and other factors as explained in the study in Bangladesh. The fraction we have taken here is 5.4% cited in the same paper which is used as a basis as exact data for Nepal was not available. Also, Nepal and Bangladesh resemble similarity as developing countries. Miah, M. A., Khan, M. A. W., Talukder, M. H. K., Begum, F., Nargis, T., Khan, T. F., ... & Ali, S. I. (2011). Reasons of Dropouts and Defaulters of Medical Students in Bangladesh. Bangladesh Journal of Medical Education, 2(2), 1-6.
dropout_rate[background]	MAX(0, MBBS_STUDENTS*DROP_OUT_FRACTION)		doctor/year	This is one of the outflow of stock. Every year certain percentage of the medical students leaves their studies which decreases the stock of total number of medical students.
FRACTIONAL_INCREASE_IN_SEATS	0.0438		dmnl/year	The fractional increase in seat is the average increment in medical college seats that has been allocated by Nepal MedicaL Council (NMC) for Bachelor of Medicine and Bachelor of Surgery to medical colleges for every academic year. Ministry of Education and Institute of Medicine publish information regarding the number of colleges medical studies and seats granted for different

				acedemic year. Information available from these sources along with the information from the website of each medical colleges allowed to identify the number of acutal seat which was then used to determine the FRACTIONAL INCREASE IN SEATS. Moreover, these values were calibrated to meet the actual number of seats.
GRADUATION_RATE [background]	DELAY3(RATE_OF_MEDICAL_STUDENTS_ENROLLMENT, MBBS_STUDY_DURATION)		doctor/year	These are the students who are graduated after completion of 5.5 year studies which decreases the number of MBBS students in every year. Therefore, it is the outflow from the students stock which is the product of the MBBS students and average graduation fraction rate
MBBS_STUDENTS[rural_background](t)	MBBS_STUDENTS[rural_background](t - dt) + (RATE_OF_MEDICAL_STUDENTS_ENROLLMENT[rural_background] - dropout_rate[rural_background] - GRADUATION_RATE[rural_background]) * dt	INIT MBBS_STUDENTS[rural_background] = 110	doctor	The stock is the accumulation of students who are studying the MBBS in the medical college and university. In order to differentiate the students background, the array is constructed. The urban and rural background are distinguished as likelihood of working in rural practice is approximately twice greater among doctors with a rural background as stated by Laven & Wilkinson (2003). therefore we assumed the same.Out of total general quota, 5% are from the rural background and the remaining from urban in Nepal.Huntington, Shrestha, Reich, & Hagopian, (2011) Every year 2200 students are enrolled in the MBBS studies. https://myrepublica.nagariknetwork.com/news/numbers-going-abroad-for-mbbs-officially-drop/ Laven, G., & Wilkinson, D. (2003). Rural doctors and rural backgrounds: how strong is the evidence? A systematic review. Australian Journal of Rural Health, 11(6), 277-284.
MBBS_STUDENTS[urban_background](t)	MBBS_STUDENTS[urban_background](t - dt) + (RATE_OF_MEDICAL_STUDENTS_ENROLLMENT[urban_background] - dropout_rate[urban_background] - GRADUATION_RATE[urban_background]) * dt	INIT MBBS_STUDENTS[urban_background] = 2090		

MBBS_STUDY_DURATION	5.5		year	Generally the medical education in Nepal is a 5.5 year curriculum based on the British medical education model as stated by Huntington, Shrestha, Reich, & Hagopian, (2011)). Thus, the value of 5.5 years is used .
"MEDICAL_COLLEGE_SEATS_CAPACITY_(MBBS)"(t)	"MEDICAL_COLLEGE_SEATS_CAPACITY_(MBBS)"(t - dt) + (NET_INCREASE_IN_SEATS_CAPACITY) * dt	INIT "MEDICAL_COLLEGE_SEATS_CAPACITY_(MBBS)" = 902	doctor/year	Nepal Medical Council allocated seats for Bachelor of Medicine and Bachelor of Surgery to medical colleges for every academic year The initial value is the number of seat capacity in year 2001. The values are obtained from every individual medical college official web sites.
MEDICAL_GRADUATES[rural_background](t)	MEDICAL_GRADUATES[rural_background](t - dt) + (GRADUATION_RATE[rural_background] + DOCTORS_RETURNING_FROM_ABROAD_AFTER_STUDIES[rural_background] - PASSING_RATE[rural_background]) * dt	INIT MEDICAL_GRADUATES[rural_background] = 100	doctor	The medical graduates includes total number of medical students who are graduated every year and also those students who are returned back from foreign after completion of their medical studies. Ever year approximately 2000 students are graduated from Nepal as per (Ministry of health and Population-Human resources for health) https://myrepublica.nagariknetwork.com/news/doctors-in-distress/
MEDICAL_GRADUATES[urban_background](t)	MEDICAL_GRADUATES[urban_background](t - dt) + (GRADUATION_RATE[urban_background] + DOCTORS_RETURNING_FROM_ABROAD_AFTER_STUDIES[urban_background] - PASSING_RATE[urban_background]) * dt	INIT MEDICAL_GRADUATES[urban_background] = 1900		
NET_INCREASE_IN_SEATS_CAPACITY	"MEDICAL_COLLEGE_SEATS_CAPACITY_(MBBS)"*FRACTIONAL_INCREASE_IN_SEATS		doctor/year/year	it is an inflow that increases the medical college seats capacity with fractional increase in medical seats.
"NMC_(NEPAL_MEDICAL_COUNCIL)_PASSING_RATE"	0.47		dmnl/year	NMC PASSING RATE is the rate at which medical graduates pass license exam in order to become a registered doctor to be eligible for clinical practise. The rate of passing the NMC varies from 41% to 53% every year. Thus, average value of 47% is used here. Huntington, Shrestha, Reich, & Hagopian, (2011)

				Nepal Medical Council, 2010
PASSING_RATE[background]	MAX(0, MEDICAL_GRADUATES*"NMC_(NEPAL_MEDICAL_COUNCIL)_PASSING_RATE")		doctor/year	It is the rate at which the medical graduates passed the National medical council exam. Every Medical graduates has to passed this exam to be registered as medical doctors and work as professionals doctor in the hospital. it is the product of medical graduates and rate of passing NMC.
PERCENTAGE_OF_RURAL_STUDENTS_IN_GENERAL	0.05		dmnl	It is the fraction of students from rural background out of total students enrolled. The value is an estimation from Huntington, Shrestha, Reich, & Hagopian (2012) reserach on Career intentions of medical students in the setting of Nepal's rapidly expanding private medical education system. Health Policy and Planning, 27(5), 417–428.
RATE_OF_MEDICAL_STUDENTS_ENROLLMENT[rural_background]	RURAL_STUDENTS		doctor/year	This inflow is the sum of rural and urban student that accumulates stock of MBBS STUDENTS. It is based on the total medical college seats capacity available every year as as allocated by NMC.
RATE_OF_MEDICAL_STUDENTS_ENROLLMENT[urban_background]	URBAN_STUDENTS			
RURAL_STUDENTS	"MEDICAL_COLLEGE_SEATS_CAPACITY_(MBBS)"*PERCENTAGE_OF_RURAL_STUDENTS_IN_GENERAL		doctor/year	These are the students who are either born and brought up in rural location and completed their education from government schooling.
URBAN_STUDENTS	"MEDICAL_COLLEGE_SEATS_CAPACITY_(MBBS)"-RURAL_STUDENTS		doctor/year	These are the students who are either born and brought up in urban location
RURAL_&_URBAN_POPULATION_SECTOR:				
DESIRED_RURAL_DOCTOR_TO_RURAL_POPULATION_RATIO	URBAN_DOCTOR_TO_URBAN_POPULATION_RATIO		doctor/person	
DESIRED_RURAL_DOCTORS	DESIRED_RURAL_DOCTOR_TO_RURAL_POPULATION_RATIO*RURAL_POPULATION/10000		doctor	

"DOCTORS_TO_POPULATION_RATIO_('00,000)"	TOTAL_DOCTORS/(TOTAL_POPULATION/10000)		doctor/person	It is defined as a doctor per people.The doctors to population ratio is obtained by dividing total doctors by total population. In order to get the ratio is 10000, the population is further divided by 10000.
ELASTICITY_OF_CRUDE_DEATH_RATE_TO_TOTAL_DOCTORS_IN_RURAL	-0.18		dmnl	This variable measures the proportional change in DOCTORS following the same proportional change in FRACTIONAL RURAL CRUDE DEATH RATE. It is set to a very low value -0.18 as historical data have shown that between 2000 and 2018 the majority of DECREASE in crude death has been due to increase in number of doctors other factors remaining constant.
ELASTICITY_OF_CRUDE_DEATH_RATE_TO_TOTAL_DOCTORS_IN_URBAN	-0.18		dmnl	This variable measures the proportional change in DOCTORS following the same proportional change in FRACTIONAL URBAN CRUDE DEATH RATE. It is set to a very low value -0.18 as historical data have shown that between 2000 and 2018 the majority of DECREASE in crude death has been due to increase in number of doctors other factors remaining constant.
FRACTION_OF_INTERNATIONAL_MIGRATION	0.02		dmnl/year	This is a fraction of URBAN POPULATION who are moving out of the country. the value 0.02 is extracted from https://www.macrotrends.net/countries/NPL/nepal/net-migration
FRACTIONAL_RURAL_CRUDE_BIRTH_RATE	0.0202		dmnl/year	This rate is stated to be 0.0202 extracted from https://data.worldbank.org/indicator/SP.DYN.CBRT.IN?end=2018&locations=NP&start=2001
FRACTIONAL_RURAL_CRUDE_DEATH_RATE	INITIAL_FRACTIONAL_RURAL_CRUDE_DEATH_RATE* (TOTAL_DOCTORS_IN_RURAL/ INIT(TOTAL_DOCTORS_IN_RURAL)) ^ELASTICITY_OF_CRUDE_DEATH_RATE_TO_TOTAL_DOCTORS_IN_RURAL		dmnl/year	It is the outflow that affects the stock of RURAL POPULATION. The study from (Shetty & Shetty, 2014) concluded that the doctors per capita (primary health care physician) had an inverse association with mortality rate (CRUDE DEATH RATE). The change in supply of doctors changes the crude death rate.
FRACTIONAL_URBAN_CRUDE_BIRTH_RATE	0.004		dmnl/year	This rate is stated to be 0.004 extracted from https://data.worldbank.org/indicator/SP.DYN.CBRT.IN?end=2018&locations=NP&start=2001

FRACTIONAL_URBAN_CRUDE_DEATH_RATE	INITIAL_FRACTIONAL_URBAN_CRUDE_DEATH_RATE*(TOTAL_DOCTORS_IN_URBAN/INIT(TOTAL_DOCTORS_IN_URBAN))^ELASTICITY_OF_CRUDE_DEATH_RATE_TO_TOTAL_DOCTORS_IN_URBAN		dmnl/year	It is the outflow that affects the stock of URBAN POPULATION. The study from (Shetty & Shetty, 2014) concluded that the doctors per capita (primary health care physician) had an inverse association with mortality rate (CRUDE DEATH RATE). The change in supply of doctors changes the crude death rate.
INITIAL_FRACTIONAL_RURAL_CRUDE_DEATH_RATE	0.006		dmnl/year	The INITIAL FRACTIONAL RURAL CRUDE DEATH RATE, exogenous parameter influences the FRACTIONAL RURAL CRUDE DEATH RATE. The rate is extracted as 0.006 from World Bank data. https://data.worldbank.org/indicator/SP.DYN.CBRT.IN?end=2018&locations=NP&start=2001
INITIAL_FRACTIONAL_URBAN_CRUDE_DEATH_RATE	0.0012		dmnl/year	The INITIAL FRACTIONAL urban CRUDE DEATH RATE, exogenous parameter influences the FRACTIONAL URBAN CRUDE DEATH RATE. The rate is extracted as 0.0012 from https://data.worldbank.org/indicator/SP.DYN.CDRT.IN?end=2018&locations=NP&start=2001
NATURAL_MIGRATION_RATE	NET_RURAL_TO_URBAN_MIGRATION_FRACTION*RURAL_POPULATION		person/year	These are the people who are leaving the rural location which decreases the population of that area. This is a outflow that depletes the stock of RURAL POPULATION.
NET_RURAL_TO_URBAN_MIGRATION_FRACTION	0.01		dmnl/year	IIt is the internal migration rate of people from rural to urban area.The NET RURAL TO URBAN MIGRATION RATE, exogenous parameter influences the NATURAL MIGRATION RATE. The rate is extracted as 0.03 per year from Tiwari(2008) report on Urban migration and urbanization in Nepal and later value is calibrated.
OUT_MIGRATION_RATE	URBAN_POPULATION*FRACTION_OF_INTERNATIONAL_MIGRATION		person/year	These are the people who are leaving from URBAN location to out of the country which decreases the population of that area.It is generally the international migration. Therefore, this is a outflow that depletes the stock of URBAN POPULATION which is the product of FRACTION OF INTERNATIONAL MIGRATION and URBAN POPULATION.
RURAL_CRUDE_BIRTH_RATE	RURAL_POPULATION*FRACTIONAL_RURAL_CRUDE_BIRTH_RATE		person/year	It is an inflow that increases the rural population which is estimated through the multiplication of rural crude birth rate with fractional rural crude birth rate.

RURAL_CRUDE_DEATH_RATE	MAX(0, RURAL_POPULATION*FRACTIONAL_RURAL_CRUDE_DEATH_RATE)		person/year	It is an outflow which decreases the RURAL POPULATION. The RURAL CRUDE DEATH RATE is determined through either maximum of zero or the product of FRACTIONAL RURAL CRUDE DEATH RATE and the RURAL POPULATION.
RURAL_DOCTOR_TO_RURAL_POPULATION_RATIO	TOTAL_DOCTORS_IN_RURAL/(RURAL_POPULATION/10000)		doctor/person	The rural doctors to rural population ratio is calculated by dividing total registered doctors in rural by total rural population. In order to get the ratio is 10000, the population is further divided by 10000.
RURAL_POPULATION(t)	RURAL_POPULATION(t - dt) + (RURAL_CRUDE_BIRTH_RATE - RURAL_CRUDE_DEATH_RATE - NATURAL_MIGRATION_RATE) * dt	INIT RURAL_POPULATION = 20951415	person	It is the stock of people living in the rural part of Nepal. The inflow "RURAL CRUDE BIRTH RATE" adds to the stock through the number of births per year and the stock is depleted by the outflow RURAL CRUDE DEATH RATE AND THE NATURAL MIGRATION RATE. The initial value of 20951415 refers to the number of people living in the remote and rural part of Nepal as documented by World bank report for the year 2000 and United Nations - World Population Prospects available at https://population.un.org/wup/Country-Profiles/
TOTAL_DOCTORS	TOTAL_DOCTORS_IN_RURAL+TOTAL_DOCTORS_IN_URBAN		doctor	It is the sum of TOTAL DOCTORS IN RURAL and TOTAL DOCTORS IN URBAN
TOTAL_DOCTORS_IN_RURAL	SUM(DOCTORS_IN_RURAL_THROUGH_VACANCY)+SUM(EXPERIENCED_DOCTORS_IN_RURAL)+SUM(NEWLY_PLACED_SCHOLARSHIP_STUDENTS_IN_RURAL)+SUM("SEMI-EXPERIENCED_DOCTORS_IN_RURAL")		doctor	It is sum of DOCTORS IN RURAL THROUGH VACANCY, EXPERIENCED DOCTORS IN RURAL, NEWLY PLACED SCHOLARSHIP STUDENTS IN RURAL AND SEMI EXPERIENCED DOCTORS IN RURAL
TOTAL_DOCTORS_IN_URBAN	SUM(ROOKIE_DOCTORS_IN_URBAN)+SUM("SEMI-EXPERIENCED_DOCTORS_IN_URBAN")+SUM(EXPERIENCED_DOCTORS_IN_URBAN)		doctor	It is sum of ROOKIE DOCTORS IN URBAN, EXPERIENCED DOCTORS IN URBAN AND SEMI EXPERIENCED DOCTORS IN URBAN
TOTAL_POPULATION	RURAL_POPULATION+URBAN_POPULATION		people	It represents the population of whole country. TOTAL POPULATION includes permanent population i.e. those people originally living there and floating population i.e. people who are migrating from the other parts of the country and leaving the

				country.This is a sum of RURAL POPULATION and URBAN POPULATION.
URBAN_CRUDE_BIRTH_RATE	URBAN_POPULATION*FRACTIONAL_URBAN_CRUDE_BIRTH_RATE		person/year	It is an inflow that increases the urban population which is estimated through the multiplication of urban crude birth rate with fractional rural crude death rate.
URBAN_CRUDE_DEATH_RATE	MAX(0, URBAN_POPULATION*FRACTIONAL_URBAN_CRUDE_DEATH_RATE)		person/year	It is an outflow which decreases the URBAN POPULATION. The URBAN CRUDE DEATH RATE is determined through either maximum of zero or the product of FRACTIONAL URBAN CRUDE DEATH RATE and the URBAN POPULATION.
URBAN_DOCTOR_TO_URBAN_POPULATION_RATIO	TOTAL_DOCTORS_IN_URBAN/(URBAN_POPULATION/10000)		doctor/person	The urban doctors to urban population ratio is calculated by dividing total doctors in rural by total rural population. In order to get the ratio is 10000, the population is further divided by 10000.
URBAN_POPULATION(t)	URBAN_POPULATION(t - dt) + (URBAN_CRUDE_BIRTH_RATE + NATURAL_MIGRATION_RATE - URBAN_CRUDE_DEATH_RATE - OUT_MIGRATION_RATE) * dt	INIT URBAN_POPULATION = 3395691	person	
URBAN_POPULATION_1(t)	URBAN_POPULATION_1(t - dt)	INIT URBAN_POPULATION_1 = 3395691	person	It is the stock of people living in the rural part of Nepal. The inflow " URBAN CRUDE BIRTH RATE" adds to the stock through the number of births per year and the stock is depleted by the outflow URBAN CRUDE DEATH RATE and OUT MIGRATION RATE. The initial value of 20951415 refers to the number of people living in the remote and rural part of Nepal as documented by World bank report for the year 2000 United Nations - World Population Prospects available at https://population.un.org/wup/Country-Profiles/
VACANCY_FOR_RURAL_POSITIONS:				
FRACTIONAL_INCREASE_IN_RURAL_VACANCY	0.034		dmnl/year	Increase in rural vacancy increases the rural doctors population but decreases the urban doctors population. The vacancy increment rate is only 3.4% from the year 1991 and 2011 as per the report of MOPH- Human Resources for Health Strategic Plan 2011-2015 Draft.
RATE_OF_INCREASE_IN_VACANCY	IF policy_status=1 THEN VACANCY_GAP/policy_adj_time ELSE		doctor/year	Every year number of Vacancy postings increases with the certain rate.

	VACANCY*FRACTIONAL_INCREASE_IN_RURAL_VACANCY			
VACANCY(t)	VACANCY(t - dt) + (RATE_OF_INCREASE_IN_VACANCY) * dt	INIT VACANCY = 424	doctor	The PSC can advertise vacancies once a year for medical officer posts. It is a stock that accumulates with the rate of increase vacancy every year. The initial vacancy is obtained from data provided by MOPH-Human Resources for Health Strategic Plan 2011-2015.(https://www.who.int/workforcealliance/countries/Nepal_HRHStrategicPlan_finaldraft.pdf) There are 1447 sanctioned posts for public hospitals out of which 335 are scholarship. so, without scholarship, the sanctioned posts is 1112 and there is only 40% going for rural positions. so, the value is 444. Some calibration has been made in the model.
VACANCY_FULLFILLED	VACANCY*VACANCY_OCCUPANCY_RATE		doctor/year	It represents the vacancy the percentage of jobs you fill out of the total number of openings.
VACANCY_GAP	MAX(0, (GAP_BETWEEN_ACTUAL_AND_DESIRED_RURAL_DOCTOR-VACANCY))		doctor	
VACANCY_OCCUPANCY_RATE	0.7684		dmnl/year	The vacancy occupancy rate is the percentage at which the vacancy is fullfilled. sometimes its not 100% vacancy sanctioned is occupied Out of total vacancy openings and sanctioned posts only 76.84% are filled positions as per the Annual Report, DoHS, 2007/08 annual report https://dohs.gov.np/
WORK_PRESSURE_AND_JOB_SATISFACTION:				
ACTUAL_JOB_SATISFACTION_IN_RURAL	MAXIMUM_JOB_SATISFACTION_LEVEL*WEIGHT_OF_INCOME_ON_JOB_SATISFACTION*effect_of_work_pressure_in_terms_of_income_per_patients_on_job_satisfaction_in_rural +MAXIMUM_JOB_SATISFACTION_LEVEL*WEIGHT_OF_WORK_PRESSURE_ON_JOB_SATISFACTION*effect_o		dmnl	It is the actual satisfaction out of maximum satisfaction, obtained by doctors while working in the rural in terms work pressure in actual income per patients treated and actual number of patients treated based on the weight assigned to them.

	f_work_pressure_on_job_satisfaction_in_rural			
ACTUAL_JOB_SATISFACTION_IN_URBAN	MAXIMUM_JOB_SATISFACTION_LEVEL*WEIGHT_OF_INCOME_ON_JOB_SATISFACTION*effect_of_work_pressure_in_terms_of_income_per_patients_on_job_satisfaction_in_urban +MAXIMUM_JOB_SATISFACTION_LEVEL*WEIGHT_OF_WORK_PRESSURE_ON_JOB_SATISFACTION*effect_of_work_pressure_on_job_satisfaction_in_urban		dmnl	It is the actual satisfaction out of maximum satisfaction, obtained by doctors while working in the urban in terms work pressure in actual income per patients treated and actual number of patients treated based on the weight assigned to them.
ACTUAL_PATIENTS_TREATED_IN_RURAL	PATIENTS_AT_PUBLIC_HOSPITAL_IN_RURAL/TOTAL_DOCTORS_IN_RURAL/ASSESSMENT_TIME		person/doctor/year	This variable represent the total number of actual patients treated by total doctors in a rural in a year. It is calculated as stock of total patients at public hospital divided by the total registered doctors rural with patients adjustment time.
ACTUAL_PATIENTS_TREATED_IN_URBAN	((PATIENTS_AT_PUBLIC_HOSPITAL_IN_URBAN+PATIENTS_AT_PRIVATE_HOSPITALS_&_CLINICS_IN_URBAN)/TOTAL_DOCTORS_IN_URBAN)/ASSESSMENT_TIME		person/doctor/year	This variable represent the total number of actual patients treated from public hospitals and patients visiting the private hospitals and clinics in urban area by total registered urban doctors in a year. It is calculated as sum of stock of total patients at public hospital and private hospitals and clinics in urban divided by the total registered doctors urban with patients adjustment time.
ANUALLY_SICK_PEOPLE_IN_RURAL	FRACTION_OF_RURAL_POPULATION_GETTING_SICK*RURAL_POPULATION*FRACTION_OF_POPULATION_VISITING_HOSPITAL_IN_URBAN_AREA		person/year	It is derived from the product between total rural population and fraction of rural population getting sick.
DECISION_TIME_FOR_MIGRATION_DUE_TO_JOB_SATISFACTION	2		YEAR	It takes some time for building and adjusting the perceptions on job satisfaction. so, The adjustment process will take place over a time delay defined as perception time of 2 years.
effect_of_perceived_difference_of_rural_to_urban_job_satisfaction_in_migration	GRAPH(PERCEIVED_RATIO_OF_JOB_SATISFACTION_IN_RURAL_TO_URBAN) Points: (0.500, 0.989960723614), (0.650, 0.948), (0.800, 0.891), (0.950, 0.703), (1.000, 0.602), (1.250, 0.160),		dmnl	It is a graphical function that shows the magnitude of the effect of difference in job satisfaction on migration. As per Holmström & Elf (2004, July), a decline in job satisfaction will cause an increase in staff attrition. Here, we assumed that staff attrition is synonym to the migration from rural to urban and vice-versa.

	(1.400, -0.102), (1.550, -0.281), (1.700, -0.382), (1.850, -0.469), (2.000, -0.500)			This effect of perceived difference of rural to urban job satisfaction in migration of semi-experienced doctors represent the tendency how semi-experienced doctors tend to move to and flow rural and urban sector depending on the PERCEIVED RATIO OF JOB SATISFACTION IN RURAL TO URBAN. The y-axis range from -0.5 to 1 for x-axis value of -0.5 to 2 suggesting that RURAL JOB SATISFACTION should increase more than 100% to trigger the movement of doctor from urban to rural. Moreover, -0.5 in y-axis suggest that only half of the normal leaving rate would migrate for more than 100% increase in job satisfaction. In the absence of literature, the shape of the graph was first estimated by the modeller based on the information derived from motivational theory and limited literature that studied income as determining factor for migration. Afterwards, the shape of the curve was validated through interview with the few doctors practicing in urban area. Holmström, P., & Elf, M. (2004, July). Staff retention and job satisfaction at a hospital clinic-a case study. In 22nd International Conference of the System Dynamics Society, University of Oxford, July (pp. 25-29).
effect_of_work_pressure_in_terms_of_income_per_patients_on_job_satisfaction_in_rural	GRAPH(RATIO_OF_ACTUAL_INCOME_TO_STANDARD_INCOME_PER_PATIENT_IN_RURAL) Points: (0.5000, 0.503346425462), (0.5500, 0.508993104981), (0.6000, 0.523712936589), (0.6500, 0.559601461011), (0.7000, 0.634470710685), (0.7500, 0.7500), (0.8000, 0.865529289315), (0.8500, 0.940398538989), (0.9000, 0.976287063411), (0.9500, 0.991006895019), (1.0000, 0.996653574538)		dmnl	It represents the number of patients treated in terms of per rupee income relative to the STANDARD INCOME PER PATIENTS to measure the Work Pressure in terms of monetary units. As we know greater the work pressure lowers the job satisfaction and vice versa.

effect_of_work_pressure_in_terms_of_income_per_patients_on_job_satisfaction_in_urban	GRAPH(RATIO_OF_ACTUAL_INCOME_TO_STANDARD_INCOME_PER_PATIENT_IN_URBAN) Points: (0.5000, 0.503346425462), (0.5500, 0.508993104981), (0.6000, 0.523712936589), (0.6500, 0.559601461011), (0.7000, 0.634470710685), (0.7500, 0.7500), (0.8000, 0.865529289315), (0.8500, 0.940398538989), (0.9000, 0.976287063411), (0.9500, 0.991006895019), (1.0000, 0.996653574538)		dmnl	It represents the number of patients treated in terms of per rupee income relative to the STANDARD INCOME PER PATIENTS to measure the Work Pressure in terms of monetary units. As we know greater the work pressure lowers the job satisfaction and vice versa.
effect_of_work_pressure_on_job_satisfaction_in_rural	GRAPH(RATIO_OF_ACTUAL_TO_STANDARD_PATIENTS_TREATED_IN_RURAL) Points: (0.5000, 1.0000), (0.5500, 0.835160023018), (0.6000, 0.724664482059), (0.6500, 0.650597105956), (0.7000, 0.600948258997), (0.7500, 0.567667641618), (0.8000, 0.545358976645), (0.8500, 0.530405031313), (0.9000, 0.520381101989), (0.9500, 0.513661861224), (1.0000, 0.509157819444)		dmnl	Workplace stress (WS) has been found to affect job satisfaction (JS) and turnover intention. The study by Chao, Jou, Liao & Kuo (2015) found that WS had a positive effect on turnover intention but negative effect on job satisfaction. It is a graphical function that shows the non linear negative relationships, as the workload pressure increases, the job satisfaction decreases. We have assumed that when workload is zero, the effect on job satisfaction is highest and when the workload is maximum, the effect on job satisfaction is least.
effect_of_work_pressure_on_job_satisfaction_in_urban	GRAPH(RATIO_OF_ACTUAL_TO_STANDARD_PATIENTS_IN_URBAN) Points: (0.5000, 1.0000), (0.5500, 0.835160023018), (0.6000, 0.724664482059), (0.6500, 0.650597105956), (0.7000, 0.600948258997), (0.7500, 0.567667641618), (0.8000, 0.545358976645), (0.8500, 0.530405031313), (0.9000, 0.520381101989), (0.9500, 0.513661861224), (1.0000, 0.509157819444)		dmnl	Workplace stress (WS) has been found to affect job satisfaction (JS) and turnover intention. The study by Chao, Jou, Liao & Kuo (2015) found that WS had a positive effect on turnover intention but negative effect on job satisfaction. It is a graphical function that shows the non linear negative relationships, as the workload pressure increases, the job satisfaction decreases. We have assumed that when workload is zero, the effect on job satisfaction is highest and when the workload is maximum, the effect on job satisfaction is least.

FRACTION_OF_POPULATION_VISITING_HOSPITAL_IN_RURAL_AREA	0.5		DMNL	It is the fraction that people who have severe illness and seeking medical attention and going to public hospitals in RURAL area for treatment.
FRACTION_OF_RURAL_POPULATION_GETTING_SICK	0.54		dmnl/year	Out of total rural population only fraction of people get ill and are seeking for medical treatment. The value of this auxilliary variable is 66.8% from the study by Hotchkiss, Rous, Karmacharya & Sangraula (1998) on Household health expenditures in Nepal: Household health expenditures in Nepal:implications for health care financing reform
FRACTIONALRURAL_RECOVERY_RATE	0.93		dmnl/year	The death rate of Nepal decreased from 8% to 6% from 2001 to 2018. so, taking the average of two years we get 7%. therefore we asssumed that death are either people being sick or through natural death, with or without seeking the health facilities. thus, the fractional recovery rate of either rural area is assumed calculated to be 93%. available from: https://www.macrotrends.net/countries/NPL/nepal/death-rate data source: United Nations - World Population Prospects
INCOME_FROM_EACH_PATIENTS_TREATED_IN_RURAL	AVERAGE_NORMAL_RURAL_INCOME/ACTUAL_PATIENTS_TREATED_IN_RURAL		rupees/people	It is money in terms of rupees received by doctors while treating each sick person in the hospital. It is calculated by dividing AVERAGE NORMAL RURAL INCOME and ACTUAL PATIENTS TREATED IN RURAL.
INCOME_FROM_EACH_PATIENTS_TREATED_IN_URBAN	TOTAL_ANNUAL_INCOME_OF_URBAN_DOCTORS/ACTUAL_PATIENTS_TREATED_IN_URBAN		rupees/people	It is money in terms of rupees received by doctors while treating each sick person in the hospital. It is calculated by dividing TOTAL ANNUAL INCOME OF URBAN DOCTORS and ACTUAL PATIENTS TREATED IN URBAN.
MAXIMUM_JOB_SATISFACTION_LEVEL	1		dmnl	This is the standard value for satisfaction. The maximum job satisfaction level is assumed to be 100%.
PATIENTS_AT_PUBLIC_HOSPITAL_IN_RURAL(t)	PATIENTS_AT_PUBLIC_HOSPITAL_IN_RURAL(t - dt) + (RATE_OF_INCOMING_PATIENTS_AT_PUBLIC_HOSPITALS_IN_RURAL - RATE_OF_OUTGOING_PATIENTS_A	INIT PATIENTS_AT_PUBLIC_HOSPITAL_IN_RURAL = 100000	people	The patients at public hospital in rural represents the stock of people who are ill and who are under medical treatments. the stock accumulates through the inflow of incoming patients and is drained through the outflows of outgoing patient rate at public hospital rural.

	T_PUBLIC_HOSPITALS_IN_RURAL) * dt			The stock is initialize at 100000 in base year 2001 which is to be assumed due to no any available data.
PERCEIVED_RATIO_OF_JOB_SATISFACTION_IN_RURAL_TO_URBAN	SMTH3(ACTUAL_JOB_SATISFACTION_IN_RURAL/ACTUAL_JOB_SATISFACTION_IN_URBAN, DECISION_TIME_FOR_MIGRATION_DUE_TO_JOB_SATISFACTION)		dmnl	This variable represents the perceived difference in job satisfaction in rural and urban. As the difference in job satisfaction increases between rural and urban, there is more discrepancy between the perception of job satisfaction among these. It is the information delay since the brain needs some time process the information and built the perception. so this ratio represents relative perceived job satisfaction in terms of actual job satisfaction in rural to actual job satisfaction in urban. If the ACTUAL JOB SATISFACTION IN RURAL and ACTUAL JOB SATISFACTION IN URBAN is lower than 1, the SEMI-EXPERIENCED DOCTORS IN RURAL and EXPERIENCED DOCTORS IN RURAL migrate from rural to urban location and if the ratio is greater than 1, the SEMI-EXPERIENCED DOCTORS IN URBAN and EXPERIENCED DOCTORS IN URBAN migrate from urban to rural location.
RATE_OF_INCOMING_PATIENTS_AT_PUBLIC_HOSPITALS_IN_RURAL	ANUALLY_SICK_PEOPLE_IN_RURAL		persons/year	It is an inflow rate that increases the patients at public hospitals in rural every year. it represents that only fraction of rural population gets ill every year and only few seek medical attention. It is defined as the flow of patients coming to the hospitals for treatment.It accumulates the STOCK OF PATIENTS AT PUBLIC HOSPITAL IN rural
RATE_OF_OUTGOING_PATIENTS_AT_PUBLIC_HOSPITALS_IN_RURAL	PATIENTS_AT_PUBLIC_HOSPITAL_IN_RURAL*FRACTIONALRURAL_RECOVERY_RATE		persons/year	This is the primary outflow from the patients at public hospital in rural. It represents the outgoing patients after being recovered from the public hospital. The outflow is controlled by presence of the patients in public hospitals in rural multiplied by the fractional recovery rate rural.
RATIO_OF_ACTUAL_INCOME_TO_STANDARD_INCOME_PER_PATIENT_IN_RURAL	INCOME_FROM_EACH_PATIENTS_TREATED_IN_RURAL/STANDARD_INCOME_PER_PATIENTS		dmnl	it represents the number of patients treated in terms of per rupee income relative to the STANDARD INCOME PER PATIENTS to measure the Work Pressure in terms of monetary units in rural. The doctor workload pressure is the ratio between the INCOME FROM EACH PATIENTS TREATED IN RURAL TO STANDARD INCOME PER PATIENTS. If the ratio is lower than 1, there is more work pressure meaning the doctors get the less amount of money treating more number of patient, which results to decline in job satisfaction and if it is greater than 1, there is less workload meaning the doctors get the more amount

				of money treating less number of patient, which results to more in job satisfaction in rural location.
RATIO_OF_ACTUAL_INCOME_TO_STANDARD_INCOME_PER_PATIENT_IN_URBAN	INCOME_FROM_EACH_PATIENTS_TREATED_IN_URBAN/STANDARD_INCOME_PER_PATIENTS		dmnl	it represents the number of patients treated in terms of per rupee income relative to the STANDARD INCOME PER PATIENTS to measure the Work Pressure in terms of monetary units in urban The doctor workload pressure is the ratio between the INCOME FROM EACH PATIENTS TREATED IN URBAN TO STANDARD INCOME PER PATIENTS. If the ratio is lower than 1, there is more work pressure meaning the doctors get the less amount of money treating more number of patient, which results to decline in job satisfaction and if it is greater than 1, there is less workload meaning the doctors get the more amount of money treating less number of patient, which results to more in job satisfaction in urban location.
RATIO_OF_ACTUAL_TO_STANDARD_PATIENTS_IN_URBAN	ACTUAL_PATIENTS_TREATED_IN_URBAN/STANDARD_NUMBER_OF_PATIENT_TREATED_PER_DOCTOR		dmnl	It is the ratio of actual compared to standard patients in order to represents the relative work pressure in URBAN area. If the RATIO OF ACTUAL TO STANDARD PATIENTS IN URBAN is greater than 1, this indicates that the more patients are to be treated by doctors than the specified standard number of patients increasing the workload pressure but if it is less than 1, there is no pressure at all in URBAN in terms of number of patients.
RATIO_OF_ACTUAL_TO_STANDARD_PATIENTS_TREATED_IN_RURAL	ACTUAL_PATIENTS_TREATED_IN_RURAL/STANDARD_NUMBER_OF_PATIENT_TREATED_PER_DOCTOR		dmnl	The doctor workload pressure is the ratio between the actual patients treated per doctor and the standard patients handled per doctor. Workload pressure value is less than one implies actual patients treated is declining with more recovery while if it is greater than 1, this indicates that the more patients are to be treated by doctors than the specified standard number of patients increasing the workload pressure.
STANDARD_INCOME_PER_PATIENTS	500		rupees/person	This is an exogenous variable. The value is an average value paid by patients in general
STANDARD_NUMBER_OF_PATIENT_TREATED_PER_DOCTOR	2100		person/doctor/year	The standard primary care panel size is considered to be 2,500 patients,available from https://www.beckershospitalreview.com/hospital-physician-relationships/how-many-patients-is-too-many-study-debunks-industry-standard.html The value used here is calibrated.

WEIGHT_OF_INCOME_ON_JOB_SATISFACTION	0.5		DMNL	There are several determinants of job satisfaction such as pay, work motivation,workload, integration as stated by Agho, A.O., Price , J.L, & Mueller ,C.W. (1993) in Determinants of Employee Job Satisfaction : An Empirical Test of Causal Model. Human Relations, 46 (8): 1007-1027. So, we have assigned the weight as 50% based on the response from few doctors's interview.
WEIGHT_OF_WORK_PRESSURE_ON_JOB_SATISFACTION	0.5		DMNL	