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A System Dynamics Approach to Healthcare Cost Control

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KEYWORDS

Health problem,
weights,
systems thinking,
system dynamics,
Expenses

ABSTRACT

The purpose of this article is to present a system dynamics (SD) model for studying the interconnections among human being weight, eating habit, exercise, body fat, take-in medication, drugs-uses, and the health problems in general. Due to the fact that all of these factors have direct and indirect impacts on the expenses that insurance company have to pay this author is proposing a systems thinking approach for determining the interconnections among the factors and uses the concept of system dynamics to simulate and determine the behavior of the system. To do so, key points about systems thinking, related theories, and system dynamics are reviewed. A model presenting the interconnections between weight factor and health problems are developed and discussed. Expense rates are classified into operational expenses (OE), treatment expenses (TE), Medication expenses (ME), Hospitality expenses (HE), and Drug treatment expenses (DE). This article makes a significant contribution to the health study issues due to the fact that it shows how a factor such as weight can have impacts on hearth attack, blood pressure, and blood sugar, to mention a few, and how relate all these to the overall expenses that an insurance company have to pay at last.

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1. Introduction

The healthcare system is large and complex, one that does not naturally lend itself to easy analysis, design, or even understanding. The complexity and critical nature of the system beg for the development and use of good, representative models (Keolling and Schwandt, 2005). Middle aged people and up are highly health conscious and pay for their health to make their pains go away. For this reason alone they are costly for insurance company and hence for their employer, as a participant in paying a good portion of their insurance bill on a monthly basis. Those who work in the office and have about minimal exercise per day are of highly potential group that gets sick, sooner rather than later. This could also be for having high stress on a daily basis. The complexity of the health system is obvious to every one these days. This is why modeling health systems with newly developed techniques or the ones capable of taking many key variables into consideration as well as their quantification, and analysis are of very high concern.

Health related costs can be broken into five categories namely the provider costs, hospital costs, technology costs, pharmaceuticals costs, and insurance costs. In 2006, physician service in US has consumed about 21% of total healthcare expenditure.

Annual average growth rate of total provider costs was 6.5%. Cost drivers for provider costs can be distributed in three different categories – physician compensation, malpractice premiums and supply and demand characteristics. Hospital costs will continue to rise by

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6.6%-6.7% each year from 2007 to 2017. Such cost rise in U.S. is a combination of price and quantity as a result of increasing inpatient, outpatient and emergency services.

In 2006, 37%, 38.5% and 14% of hospital costs were nearly absorbed by private insurance companies, Medicare and Medicaid respectively (American Medical Association, 2006).

Other hospital cost drivers are – (1) wage pressure and physician charge, (2) the 3C's (consolidation, competition, and construction), (3) technology acquisition and use, (4) government payment levels and (5) hospital support system. Nursing shortages spurred significant increases in wages forced hospital administrators to offer higher salaries, signing bonuses, more flex time and also results in hiring more temporary staff. Hospital technology usage also increased in terms of more modern technologies and applications i.e. MRI, catheterization and other diagnostic services (American Medical Association, 2006).

Technology and Pharmaceuticals are major drivers of healthcare cost: In the past five years medical technology spending comprised about 20% of the growth in healthcare costs and now exceeds $200 billion annually. There is substantial evidence that overutilization and misuse of technology leads to spending that exceeds its value for patients. Diagnostic imaging technology increased nearly to a $100 billion business (Beever, Bums and Karbe, 2005). In 2006, $637 billion global pharmaceutical market was dominated by the United States.

In recent years, U.S. shifted into an ownership society away from a welfare society. Insurance premium cost increased by 42% in the last five years from 2002-2007 (National Health Expenditure Report, 2008). Premiums for employer-based health insurance rose by 6.1% in 2007. Administrative cost also contributes to higher premiums. The U.S. spent roughly 31% administrative costs or $1000 per person in 2007 which is significantly more than double as compared to Canada's costs.

Keolling and Schwandt (2005) in their article entitled "Health Systems: A dynamic system-benefits from system dynamics" have classified healthcare systems as shown in table 1.

The very best way for representing the health system architectures is through the use of causal loop diagrams that are considered a powerful way for the representation of complex systems, in general. For example Hirsch et al. (2005) explore the health system from the perspective of population health dynamics (Keolling and Schwandt, 2005).

The authors expand the basic model to consider the effects of things such as high tech medicine, fragmentation of services, cost containment, living conditions, and patient involvement. Their proposed model integrates all of these effects rather than considering them individually, demonstrating a strength of SD modeling.

Tab. 1. Classification of healthcare systems (Keolling and Schwandt, 2005)

Category	Description
Health Systems	Strategy and policy studies at the national or international level
Systems	Strategic and policy studies, typically within organizations, at the regional or metropolitan area level.
Clinical	Strategic and policy studies, typically within organizations or within a single facility
Delivery	Typically focused studies, typically within a single facility or a department within a facility
Prevention	Studies focused on the prevention of illness, disease, or incidents and the impacts of prevention strategies and tactics
Epidemiology	Studies focused on the spread of illness or disease or the physiological understanding of an illness or disease.

The healthcare cost drivers have increased significantly in the past few years. Among all the healthcare cost drivers, personal healthcare, health service and supplies tend to increase or remain at a steady growth rate of 6-8%. Physician and clinical services tend to increase by 5.7 to 8.1% (The Henry J. Kaiser Family Foundation, 2007, An, Saloner and Ranji, 2008)

Healthcare premiums have continuously grown faster than inflation or workers' earning in recent years. Between 2002 and 2004, the cumulative growth of health insurance was 78% compared to the cumulative inflation of 17% and cumulative wage growth of 19%. (The Henry J. Kaiser Family Foundation, 2007).

The Canadian and VHA (Veterans Health Administration) experiences have resulted into following remarkable results (between 1994 and 1999):

1. A cost reduction of 25% (constant dollars), while providing higher quality care and more of it

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2. The closure of 55% of the acute care beds
3. A 12% reduction of staff, although 700,000 (24%) more patients received care
4. A 36% reduction in inpatient admissions
5. An increase from 35% to 75% in ambulatory surgeries as percentage of surgeries
6. A 68% reduction in bed days
7. A substantial increase in patient satisfaction, surpassing the average ratings nationally in all industries and private hospitals.

Grossman (1972a) developed a dynamic model for health and then a solution for the dynamic optimization problem that leads to the optimal life-cycle health paths, gross investment in each period, consumption of medical care (which is seen as a derived demand) and time inputs in the gross investment function in each period.

Using the original study and US data, Grossman found positive effects of education and wages on the demand for health. It also was shown that age had a positive effect on health demand and a negative effect on medical care (Grossman, 1972a, 1972b, 2000, and Jones et al., 2003).

Systems thinking combine an array of methods and techniques drawn from various fields such as engineering, computing, cybernetics, and cognitive psychology. It allows managers to overcome the feeling of helplessness when confronted with complex problems.

It gives them the necessary tools to analyze, understand, and influence the functioning of the systems they are trying to improve. Recent developments in SD demonstrate the importance of involving the people in the problematic situations early into the mapping process in order to "capture" their mental models and elucidate their knowledge about the possible causes of the problem (Vennix 1996, Vennix and Gubbels 1992, Morecroft and Sterman 1992).

System dynamics has a long history analyzing complex problems in a variety of application domains, ranging from environmental or public policy, corporate strategy, security, healthcare, and operations management, to change management. However, it has not seen extensive application in the marketing literature (Richardson and Otto, 2008).

The characteristics of the healthcare decision environment – having multiple inputs and outputs, serious effects, log lasting, with nonlinear behavior – are precisely the characteristics that demand the use of dynamic system for modeling with intuitively managing the system.

These lines of thinking are reflected in this work, aiming to provide cognitive support for healthcare managers in planning, policy analysis, and strategic decision-making.

The purpose of this article is two folds. To show (1) how systems thinking can be used for studying health problems using interconnections among the factors and (2) how a stock and flow diagram can be used to develop a dynamic model for calculating the overall cost for the insurance. Such a research is needed to determine the capability of these tools for complex model building and analysis.

The rest of this paper is organized as below: section 2 describes the methodologies of this study while systems thinking is discussed in section 3. Section 4 is about the theories of systems thinking while dynamic thinking diagram is given in section 5. The systems thinking patterns of the samples are discussed in section 6. In sections 7 and 8, we have discussed the level and rate type variables and system dynamics, respectively.

Example problem is the topic of section 9 while research limitations and propositions for research extensions are presented in section 10 and 11, respectively.

Author's discussions and conclusions is the topic of section 12. Since, to the best of this author's knowledge, this is the first study that relates weight to health problem using systems thinking concepts and system dynamics approach it makes significant contribution to health literature.

2. Methodology

The purpose of this article is two folds: (1) to show how systems thinking can be used for the study of basic health problems and the way of tackling some health models for discussing the problem; and (2) how a stock and flow can be employed to develop a dynamic model for calculating the heart attack related death patterns over time.

In addition to that, it demonstrates the use of systems thinking and dynamic systems in the area of healthcare management for better analysis of the systems and productivity enhancements. Such a research is needed to determine the capability of these tools in complex model building and analysis. A brief description of systems thinking and dynamic systems are provided for introducing the topic to a group of new readers, however. More specifically, we can identify the following list of objectives for achieving the overall goal of this study:

1. Identifying system variables within the human-being body-system taking the principles of Cybernetics into consideration.
2. Generating the causal loop diagram for the human-being-system using the identified variables from 1.
3. Flow diagrams construction.
4. Developing the mathematical formulating of the problem.
5. Model simulation using the predefined values.

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6. Conclusion and propositions.

3. Systems Thinking

Systems thinking allow consideration of the whole rather than individual elements and representation of time related behavior of systems rather than static "snapshots" (Senge 1990). Systems thinking combine an array of methods and techniques drawn from disciplines such as engineering, computing, cybernetics, and cognitive psychology. Systems thinking allow managers to overcome the feeling of helplessness when confronted with complex problems. It gives them the necessary tools to analyze, understand, and influence the functioning of the systems they are trying to improve. Some of the topics associated with systems thinking are: causal feedback (Richardson, 1991); stock–flow structures and open and closed systems (Sterman, 2000); centralized, decentralized, hierarchical, and self-organizing systems (Kauffman, 1995); nonlinear systems and chaos (Strogatz, 1994); cybernetics (Francois, 2004); and system dynamics (Forrester, 1961, 1994, 2003), (Richardson, 1996).

A number of theoretical frameworks for problem-solving that adopt systems thinking have been presented in the literature. Some examples include Soft Systems Methodology, Spiral Dynamics, Systems Intervention Methodology, and Value Systems Theory. Life cycle assessment is a particular tool for systems thinking problem-solving that has been prominent in the literature. Such assessments look at entire cycles that exist in systems.

The concept of system thinking is derived from a computer simulation model, created in 1956 by Professor Jay W. Forrester of MIT to deal with management problems in enterprises. Then, Senge and Lannon (1990) applied this concept to organization research, and advocated that for effective application of system thinking, researchers have to pay attention to the four tiers/levels in the system: event, behavior pattern, structure and mental pattern. System thinking is important because the society is full of dynamic complexity.

The term dynamic complexity was coined in by Senge and Lannon (1990) to indicate the real world we live in is actually composed of numerous causes and effects. People often concentrate on individual events and forget to consider the entire environment, and thus confine themselves to thinking in parts rather than whole. Therefore, to solve dynamic complexity, we need the assistance of system thinking to clearly see the relation between all problems and prevent the phenomenon that a change in one part affects the whole.

The operation of an enterprise is just like a small society. We start system thinking by realizing a simple concept, 'feedback', which explains how actions intensify or offset each other, and whose ultimate aim is to clearly see the simple structure behind the complicated events so as to simplify social problems.

4. The Theories of Systems Thinking

Systems archetype is composed of many circulations formed as a result of all kinds of problems that affect one another in society. Senge and Lannon (1990) classified these circulations into nine major systems archetypes: (1) Delayed balancing process; (2) Limitation to goals; (3) Shifting the burden; (4) Temporary solution; (5) Escalation; (6) Success; (7) Common tragedy; (8) Failure; (9) Growth and underachievement; (10) Fixes that Fail; and (11) Accidental Adversaries. In the section that follows we describe two of these basic system thinking's theories.

4.1. Drifting Goals

The Drifting Goals structure is composed of two balancing loops which interact in such a way that the activity of one loop actually undermines the intended balance the other one seeks to achieve. The Desired State (expected quality level by the insured) interacts with the Current State to produce a Gap. This Gap influences Action intended to move the Current State (present level of quality for the insured) in the direction of the Desired State.

At the same time, the Gap influences Action it creates a Pressure to Adjust Desire (pressure for making adjustment in quality level by insurance company). This pressure essentially acts as an influence to reduce the Desired State. As the Desired State is undermined it works to reduce the Gap lessening the influence toward Action. The final result of this structure is that it reaches an equilibrium stage other than what was the initial Desired State.

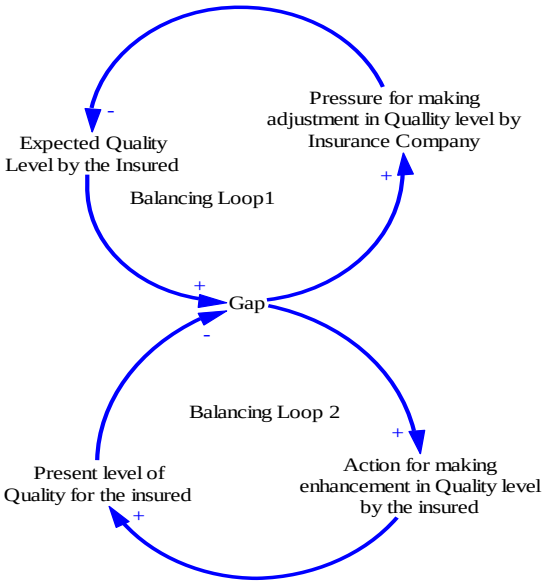

Fig. 1. Drifting goals

4.2. Fixes that Fail

Using the balancing loop, insurance company tries to bring the number of visits made by the patient to an

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expected level acceptable for the company in the long run.
For this purpose, the company's policy makers had come up with the new idea of taking an action which is nothing but asking for copayment from the insured for each visit that they have to the doctor's office. Although, on the long run the copayent will have a good effect on the current number of visits to doctor office it will push some patients away from the doctor's office and hence some of the sickness will be either worsen or some known ones left untreated for a while. As a result of that the patients get hit with the deeper problem and hence more visits to the doctor's office could start.

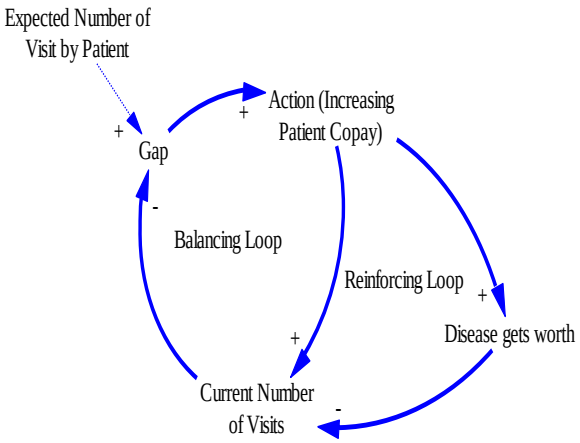

Fig. 2. Fixes that Fail

5. Dynamic Thinking Diagrams

Systems Dynamic (SD) modeling offers a unique opportunity to improve decision-makers' understanding of the sources of their systems' under-performance as it allows both qualitative and quantitative analysis, which lead more easily to consensus building, improved shared understanding, and enhanced organizational learning (Wolstenholme 1993).
With regard to a model proposed, once the researcher is able to identify the qualitative structure describing the problem situation, which are being used in the Causal Loop Diagrams (CLDs), the next step is to build a computer-based behavioral model reflecting the qualitative structure.
The stocks (variables subject to accumulation and depletion processes over time) and the flows (which determine the time related movement of units from one stock to the others) are determined and the relationships between them defined. In this phase, a link is established between the variables and their dynamic behavior. The quantitative nature of this phase makes it the most important one in terms of generating insights about the situation. It is important to notice here that many specialist software programs have been written for SD modeling (Richmond 1987, Richardson and Pugh 1981) to make the process easy and accessible to people even without strong computational background.
The system dynamic modeling approach originated from the research of Professor Jay W. Forrester at MIT in the late 1950 s. In 1956, Professor Forrester started the System Dynamics Group at the Sloan School and with it, the field of system dynamics. In his pioneering book on the subject, Forrester (1961) presented the dynamic analysis of a business problem through a model of a production-distribution system that shows oscillatory behavior.
Policies to improve system performance were discussed, and numerous policy experiments were demonstrated. Since then, system dynamic modeling approach has become a powerful tool for analyzing complex systems. Lyneis (2000, p. 3) highlight three important advantages of system dynamic modeling approach:

1. System dynamics models can provide more reliable forecasts than statistical (non-structural) models;
2. System dynamics models provide a means of understanding the causes of industry behavior; and
3. System dynamics models allow the determination of reasonable scenarios as inputs to decisions and policies.

System dynamics is typically used for models that represent relationships between system variables, rates of change over time, and explicit feedback. Rather than focusing on individual transactions in the system, the models focus more on the levels of variable stocks and the flows between variable states. As a result, SD models are more often associated with higher level types of problems, especially consideration of the impact of policy and strategy decisions.
Dynamic Systems Diagrams are composed of four different components: Levels, Rates, Auxiliary variables, and Connectors. The labels may vary slightly in different arenas. In relation to Dynamic Systems diagrams, the following points are correct: (1) Rates influence Levels (state variables); (2) Levels can influence rates or auxiliary variables; (3) Auxiliary variables can influence Flows or other Converters; (4) Auxiliaries cannot influence Levels; and (5) levels cannot influence other Levels.
Systems Dynamic modeling has been applied, in specific healthcare management issues such as healthcare work-force planning and emergency healthcare provision (Royston et al 1999, Lane et al 2000), weight related healthcare problems (Zare Mehrjerdi, 2012b), effect of joint healthcare provision by different sectors (Wolstenholme 1999), and the effect of a shift from the free-to- service to self-paying service (Hirsch and Immediato 1999). In addition to

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that this author (Zare Mehrjerdi, 2011a, 2011b and 2012a) has applied System dynamic model to library cost control and then in demonstrating the probitability feature of the quality function deployment in the industries as well as the service industry.These models demonstrate the rich variety of areas in which SD may play a significant role in health policy design.

6. Systems Thinking Patterns of the Sample Situations

On the basis of authors' observations and experiences as well as many opinions gathered by the field specialists and people in general, the model used in this study is built upon the human being body-operations and the way important parts of body perform and interact with other parts. Figure 3 illustrates various situations and then figure 4 concentrates on the expenses that an insurance company would encounter. The U.S. Healthcare costs represent a vast array of complex economic factors. Cost drivers can fit into three categories – (i) price of the goods and services, (ii) quantity of goods & services being delivered and, (iii) healthcare delivery system itself.

The cause and effect diagram in Figure 3 displays the categorical cost drivers and sub-drivers that affect the overall healthcare cost growth and total dollar spent. The major U.S. healthcare cost drivers distributed in six different categories are – (1) Provider costs, (2) Hospital costs, (3) Technology costs, (4) Insurance costs, (5) Consumer behavior, and (6) Flawed management.

Figure 3 considers a big picture in order to find all causes that have impact on the expense rate and hence on the total expenses that an insurance company must pay to run the business. The expense variable rate is comprised of influential rates as such as operational expenses (OE), treatment expenses (TE), Medication expenses (ME), hospitality (H), and Drug treatment (DT). Note should be taken that drug treatment can have serious impacts on the total expenses if attention is not paid to the drug test at the time of writing health insurance contracts.

The objective of system dynamics study is to attain some desired goals through modifications of the system. For this, a system boundary is defined and a model of the system is built (Khanna, 2004). The systematic procedural steps in SD modeling include the following as discussed by Roberts (1978) and Spencer (1966):

1. Define the problems to be solved and goals to be achieved.
2. Describe the system with a causal loop/influence diagram.
3. Formulate structure of the model, i.e. develop the flow diagram for systematizing symbols, arrow designator and the format of system dynamic modeling in the form of DYNAMO equations.
4. Collect the initial data/base data needed for model operation either from historical data and/or from discussion with the executives/planners having knowledge and experience of the system under study. These are the initial value of all the level variables, constants and policy data.
5. Validate the model on some suitable criteria to establish sufficient confidence in the model.
6. Use the model to test various policy actions to find the best way to achieve prescribed goals.

7. Level and Rate

Dynamic systems deal with two types of variables known as level and rate. The 'Level' refers to a given element within a specific time interval. In dynamic systems, level type variable is the one that accumulation occurs in that.

Meanwhile, the rate variable causes the increase or decrease in the accumulation, the level variable. The level is calculated from the difference between a rate variable that increases the level and a rate variable that reduces the level.

Specifically speaking, the level deals with rates related to input and output. Therefore, the value of level can be identified easily. Determination of rate is not a simple task and requires a great deal of effort in almost all the cases for about every problem. Most of the time a rate is calculated by finding the average value of the accumulated level over the total time taken to get that. In some cases rates are defined according to following formula:

$$\text{Rate}(t) = \text{Const} * \text{Level}(t-1)$$

Const= A predetermined value

Using the Formula for the rate given above one can determine the Level variable at time t as a function of the Level variable at time (t-1) as shown below:

$$\text{Level}(t) = \text{Level}(t-1) + DT * \text{Rate}$$

The above formula can also be written as follow:

$$d(\text{Level}) / dt = \text{Rate}$$

In above formulas, dt stands for a time period that we are looking into the changes. This time period is defined by the researcher as a minute, day, week, month, year, or others.

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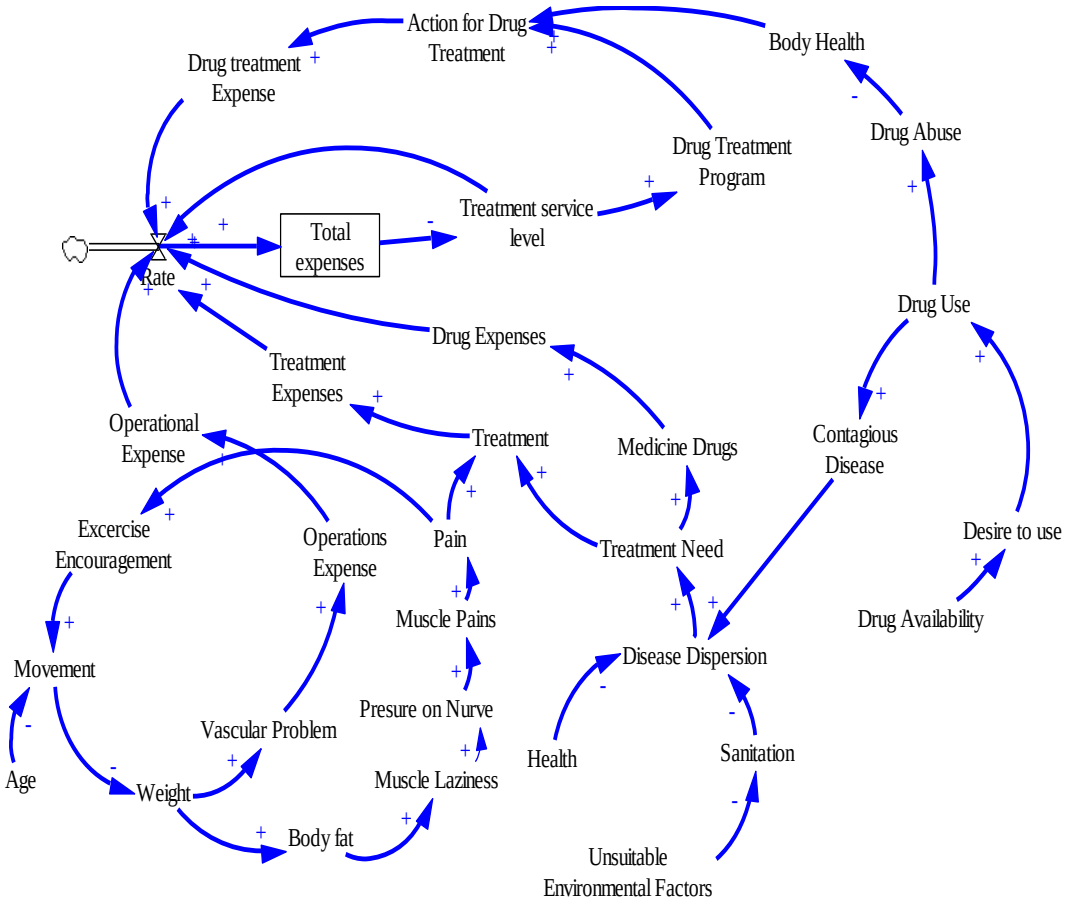

Fig. 3. A flow diagram for total expenses and its related causes

8. System Dynamics

The model proposed by Figure 3 is simplified and shown in figure 4. By finding the values of variables of OE, TE, ME, HE, and DE, then the value of expense rate RT can be determined. The variables used in this model are as defined below:

RT= rate
Total_Expense (t) = tatol expenses at period t
DT = represent time variable, usually set to 1
Const = represents a constant value

Using following general equations when RT and DT and constants are given then a simulation of the model becomes possible.

Total_Expense (t+1) = total_Expense (t) + DT * RT (t, t+1)
RT (t, t+1) = Const * Total_Expense (t)
Const = a pre determined amount
DT = 1

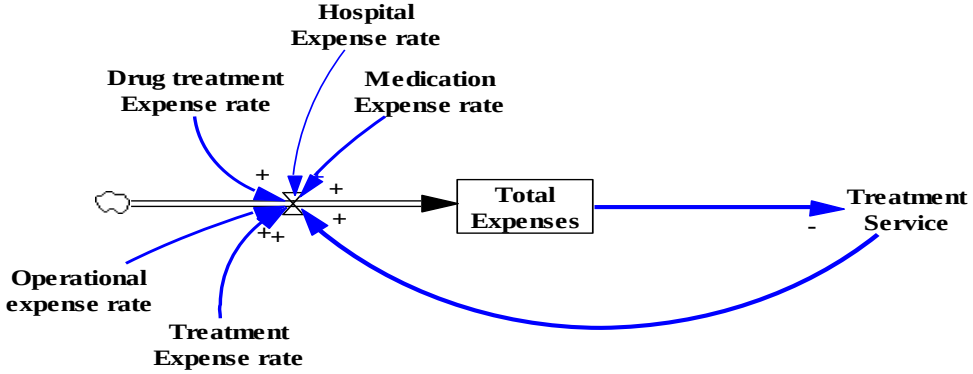

Fig. 4. A shortened flow diagram for total expenses and treatment services

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8.1. Model Verification

Vensim PLE software has capability for verification purposes. For this purpose, the "structure check" which includes "formulas check" and "units check," is used to find whether there are formulas or units errors in the model of the problem. After successful completion of checking the formulas and units loaded into the software the model of choice is simulated.

8.2 Model Validation

Vensim PLE allows model validation using the "reality check", the option that the system provides. One can use that for comparing simulation results with perceived reality. The smaller difference between them can guide us that model is adequately addressing the problem to which it is being applied.

9. Example Problem

Model formulation is as shown below:

Model of the Probelms:

Exp (t+1) = Exp (t) + DT * RT (t, t+1)

R (t, t+1) = R1 + (1+S_k) * R2 + R3 +R4 + (1+S_k) * R5

Initial Values:

Exp (t=0) = 1000000

R1=Hospital expense rate=0.006

R2=Medication expense rate=0.003

R3=Drug treatment expense rate=0.005

R4=Operational expense rate=0.004

R5=Treatment expense rate=0.001

S_k = Service Level = 0.000000001

T=1 month

Simulation Length=60 periods

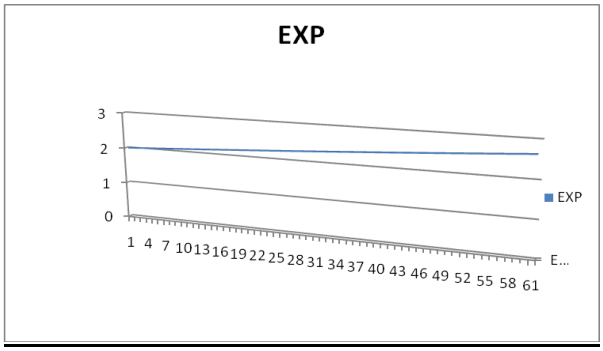

Fig. 5. The level of expense by period

Figure 5 shows the total expense for the health insurance company taking the impacts of all variables rates of operational expenses (OE), treatment expenses (TE), Medication expenses (ME), hospitality (H), and Drug treatment (DT) into account. Also, this model considers the impact of treatment service as a feedback loop on the expenses for not serving the customer when expenses go higher the level of company's expectation. We assumed that this treatment service rate is random and changes from one period (year) to the next period. Figure 6 illustrates the treatment service random rates that are raging from zero to 0.025.

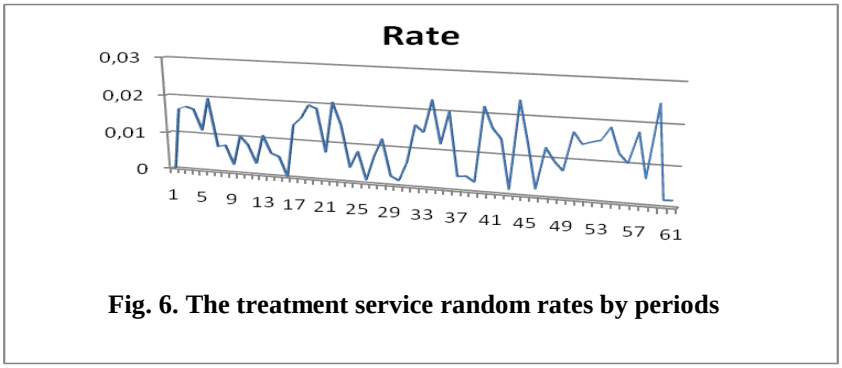

Fig. 6. The treatment service random rates by periods

10. Research Limitations

As it is stated by Sterman (2000) "All models are wrong, so no models are valid or verifiable in the sense of establishing their truth. The question facing client and model builder is never whether a model is true but whether it is a useful one". We can only say dynamic system is a good tool for studying complex systems. Specially, for a system as such as human being body with all the complexities that it has. To do a deep study on that, we are in need of trustful data.

11. Propositions for Research Extension

One of the central issues of health systems and health providers around the world is to research on the problems that can be used for showing the insured that taking care of their personal body is a good business for them.

This, in turn, would be very good for insurance companies as well. So it seems a harmonious way with insurance companies to use SD in health problems and related system modeling. With this taught in mind, this

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author proposes the following areas of concern for future researches:

Proposition 1: The overall systems' cost when obesity and blood pressure are common phenomenons among people.
Proposition 2: The overall systems' cost when obesity, blood pressure, blood sugar, and hearth problem are under control.

Preposition 3: The overall systems' cost when exercise is a common practice among the people.

Proposition 4: The overall system's cost when people are well educated about their weights, diets, and their impacts on their heart problem.

As can be seen from Figure 3 one can study the impacts that movements, exercise, weight and vascular problems may have on the overall systems' cost and hence on its behavior.

12. Discussion and Conclusion

Due to the fact that limited numbers of studies conducted on the healthcare systems cost and hence its behaviour, this article may act as a starting point for conducting research in this tremendously important area. Some regions of the world have started to work on healthcare cost studies but they are still far from that ending that could be reached. Other regions also are in need of having serious studies on their healthcare cost to have it under control and managed it wisely. It is to this end that this article makes a significant contribution to this highly important body of the research, hoping that to be taken serious in developing countries too.
The list of propositions for cost study is an exhaustive one while only four of them are identified in section 11. There are also some limitations to the study that each should be taken seriously at the time of modelling the problem.
One of these limitations, that are common in all sectors of the business in this country, is the reality that researchers are unable to put their hands on the real data. It is obvious that without real data researchers cannot find a true and meaningful behaviour for system's cost and hence management cannot make accurate decisions, timely. To deal with this problem, researchers have to imply some data that are either close to the reality or some data that may be randomly generated for that purpose. The latter happens often in most studies, due to the lack of support or data accuracy.
In this article, a flow diagram of model is constructed and the overall expenses are studied. To clearly identify rates, expense rates are broken into operational expense rate (OE), treatment expense rate (TE), Medication expense rate (ME), Hospitality expense are (HE), and Drug treatment expense rate (DE). From there it was able to find the overall system cost for the proposed model, however. This article makes a significant contribution to the health study issues due to the fact that it shows how a factor such as weight can have impacts on heart attack, blood pressure, and blood sugar, to mention a few, and how relate all these to the overall expenses that an insurance company have to pay at last. Since, to the best of this author's knowledge, this is the first study that relates weight to health problem using systems thinking concepts and system dynamics approach it makes significant contribution to health literature.

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