An Analysis of the Health Care Industry Dynamics

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Bachelor of Art in Policy Management, 1999
Keio University

Submitted to the Department of Civil and Environmental Engineering
in Partial Fulfillment of the Requirements for the Degree of

**MASTER OF ENGINEERING IN CIVIL AND ENVIRONMENTAL ENGINEERING
AT THE
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
JUNE 2002**

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Abstract

The introduction of information technologies to health care organizations is believed to improve the delivery of health care process and bring a great deal of benefit to the society. However, due to the lack of understanding in the nature of such organizations, many system providers have failed to implement their technologies to their fullest potential.

The goal of this thesis is to present an analysis of health care industry and provide useful insights that help system vendors understand the complexity of the environment. The methodology chosen is system dynamics. A simulation model was developed based on a series of interviews conducted with physicians. After performing sensitivity analysis on the model it is determined that only through controlling the inflow of potential patients can any meaningful reduction in physician workflow be achieved.

Thesis Supervisor: John R. Williams

Title: Associate Professor, Civil and Environmental Engineering

Acknowledgement

I would like to take this opportunity to thank those who have supported and encouraged me throughout three years of advanced educational experience here at MIT.

First and foremost, I would like to thank my family, Shoji, Chie, Akira, Masako, Shigeru, Ken and Uncle Akira and Aunt Yoshiko for their love and support.

I would also like to thank Dr. Mikio Shoji for his encouragement to pursue advanced education here at MIT.

I also thank to my colleagues -Andrew Ferriere, Glorimar Ripoll, Pai-Fang Hsiao, Sakda Chaiworawitkul, and Tashan Yen.

In Addition, I would like to thank Anthony Rogers, Bryan Bergeron, Daniel Sands, P.J. Huang, and Tricia Bourie for their great insights and wisdom from the health care professional point of view

I am also grateful to John A. Rassias, Professor, Dartmouth Collage, for his kindness and help for improving my English skills.

Also, I would like to thank my thesis and project supervisor, John R. Williams, for guidance and patience through the year.

Finally, my sincere gratitude goes out to my soul mate, Sachi Nagaoka, for her continued love, encouragement, and confidence in my ability.

I feel privileged that I can conclude my three years of education at MIT with the completion of Master of Engineering Program.

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Chapter1 -Introduction

1.1 Background & Problem Statement – Industry Overview

1.1.1 The market

The health care industry in the United States has become a 1.2 trillion dollar industry as of the year 2000. It almost doubled in market size since early 1990 and is 1.7 times larger than the European market. In the United States, the industry consists of three important parties: (1) payers such as the government and insurance companies, (2) service providers such as hospital, and (3) physicians, nurses and patients. The Government's yearly expenditure on medical service has increased significantly in the last thirty years. According to a projection for 2008, the U.S. Federal government is expected to spend 24.5% or $620 billion, of the federal budget on Medicare and Medicaid, compared with 17.9% or $319 billion, in 1998. This trend is still escalating as the aging of society progresses.

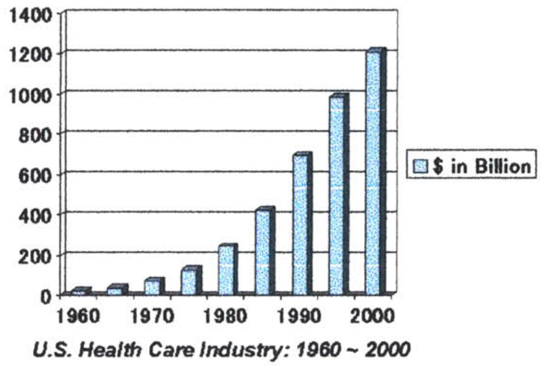


Figure 1.1 Industry Market Size

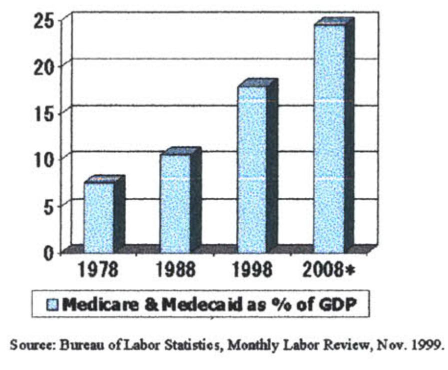


Figure 1.2 Government Expense on Health Care

1.1.2 General Trend in the Industry

The changes that have occurred in the health care industry can be categorized into three groups: (1) regulatory changes, (2) changes in the patient's mentality, and (3) changes in the business structure.

Changes in the regulations started as new technologies developed. For instance, as new technologies such as electronic patients records started to get attention, the United States Congress recognized the importance of establishing unified guidelines for the future. Therefore, congress passed the *Health Insurance Portability and Accountability Act of 1996 (HIPAA)*. The main purpose of HIPAA is to set a formal privacy and security guideline for health care related information management.

Regulations are not the only change in the health care environment. Patients' attitude toward health care has also changed. Rising patient consumerism is one of those changes. Diffusion of informed consent, increasing number of hospital visits per patient, and increasing accessibility to health related information through the Internet are educating patients more about their health condition and medication.

Corresponding to such fundamental change in the environment, hospitals are forced to make major changes in its system. One of these changes is the hospital financing structure. Today, some large private hospitals are trying to adopt a service-based charge system. Traditionally, they used a capitation scheme that limits their inability to be financially sound. Service-based charges give stronger incentive for hospitals to increase their operation efficiency. This is an appropriate strategy, particularly since the need for medical service has increased significantly over the last two decades.

These changes are still progressing and creating a more complex business environment rapidly.

1.1.3 Industry Issues and concerns

The primary concern for health care organizations these days is the rapidly growing demand for medical service, which grows as a result of an aging society. As it has been observed in the last ten years, the fear of having insufficient capacity to meet such high demand appears to have become a reality. Excess demand could cause a serious damage to the entire health care system in the long term.

Overwork for physicians is one of such damages. Today, physicians and nurses are working harder and longer hours than ever before. Yet, patients still queue up to request more medical services.

Consequently, diminishing quality of medical service occurs as the overwork issue becomes serious. Under the tight constraint of budgets, human resources, and time, excess demand for medical services can seriously have impact on the quality of service over time.Hospitals have two main choices to maintain high quality of service, while dealing at the same time with increasing demand. One is to reduce that demand, by not accepting any more patients than their capacity allow for. The second choice is to improve their operation efficiency. Today, many hospitals have chosen to go for the latter option. They are currently interested in introducing information technology (IT) as one of the methods to achieve such an objective.

1.1.4 Industry Problem Summary

After more than twenty yeas since people realized the terrifying future of the social security system, the fear of losing an affordable and quality health care is about to become a reality. The fundamental shift in the demography forces significant changes in the environment surrounding health care organizations, such as the Balanced Budget Act of 1997, rising consumerism of patients, increasing government and public oversight, change in regulatory requirements, and rising prescription. Today's health care organizations are feeling pressure as never before.

1.2 Existing Solution

1.2.1 Current Solution: Solutions already implemented

The adoption of the IT within the hospitals in the United States has been progressing gradually over the last ten years. The movement started with the adoption of the electronic patient records system, because hospital administrations believed that it could improve efficiency by reducing unnecessary paper work. Administrators also believed it would not lower the quality of medical practice, since those data were mainly used for administrative duties, such as billing.

Once they adopted IT for administrative purposes, they then tried to implement the system in actual clinical practice. Specialists, like laboratory technicians and radiologists, became the first adopters. Their adoption of IT in practice significantly improved the efficiency of hospital operation because of the increased accessibility to critical patient information such as X-Ray pictures and blood test results. IT also contributed to the storage and management of critical data in a more organized way.

Today, implementation of the hospital information system is facing a new challenge with the issue of system integration. One of the reasons why integration was so difficult to achieve is because every department has different systems. For example, Massachusetts General Hospital, the largest hospital in New England, has at least seventeen different systems. Integration was made even more difficult by the fact that systems are required to carry out daily operation without interruption.

Another reason is because there has been no standard format. For instance, the name of any particular field for the same information may be different in the two different departments' database. Some of the departments have the same information with different field names. These kinds of small differences among systems make it difficult to integrate disparate systems. The introduction of HIPPA compliance may resolve this issue in the near future.

Also, the lack of vision as a whole contributed to the challenge as well. Historically, as briefly described in the previous section, introduction of a system started gradually field by field, or department by department, as an experiment. During these processes, each department made its own decisions regarding the kind of systems it was going to use without consensus from and coordination with others. This is because each field in medical practice is highly specialized, and the characteristics of information being handled vary according to the field where that particular physician belongs. Consequently, so many different types of systems were introduced without consideration given to other departments. This resulted in the development of integration difficulty. Weak leadership from hospital management through these processes regarding purchase decisions surely contributed to the current state of affairs.

1.2.2 Our solution: Prototype and features

Through our eight months thesis project for the Master of Engineering Program at MIT, we have tackled the very same issue that many hospitals are coping with. Our goal is to identify and develop a more effective solution for these real challenges by using an information system that would help hospitals improve their operation efficiency. Thus, the primary focus of our prototype was the integration of the scattered system and database across the hospital, and provision of necessary information for physicians' decision making.

Our proposed solution consists of two main components. One is the on-site clinical information system, and the other is the off-site home monitoring system. The on-site system provides support for better decision-making by doctors and is primarily used in the hospital. This system inherited many of its features from systems already in place.

The core value for the off-site system is patient monitoring. The system adds new value to existing clinical systems because it reduces the physicians' workload.

One of the reasons why a doctor's workload has increased considerably these days is the growing number of patients with chronic diseases. Today, not only old people but also young children are struggling with these kinds of diseases. As a result, the number of patients that a doctor has to take care of increases sharply and is creating a very serious gap between hospital capacity and demand by this group of patients.

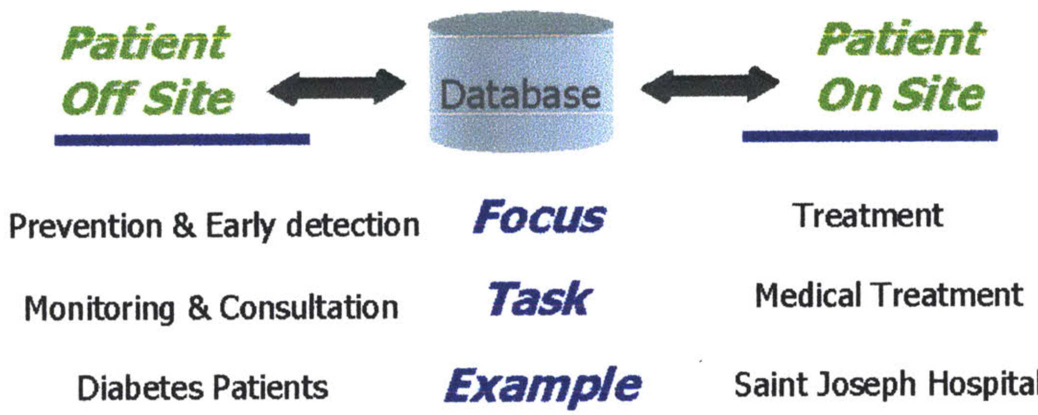


Figure 1.3 On-Site and Off-Site System

We believe that the integration of these two types of systems will improve efficiency of hospital operation and become a great alternative for doctors to maintain an intimate relationship with patients, while at the same time reducing their workload. For instance, the patients' monitoring system allows physicians to communicate with patients without their physical presence in the hospital. Furthermore, this allows physicians to maintain the same level of commitment. Consequently, patient visits can be reduced. This will enable the physicians to acquire more flexibility with their schedule.

Based on the above concept, a prototype was developed. The purpose of this prototype is to demonstrate our idea for the next generation hospital information system. Because of given time constraints, limited resources, and considering the purpose of this prototype, a boundary for the prototype was set as follows. First, focus on specific diseases such as diabetes and hypertension was strictly implemented. Second, a sample patient database was created instead of dealing with legacy systems and databases that hospitals are currently using. Third, security issue was not given top priority. Log-in and password check is the only security feature that is currently implemented.

1.3 Purpose

This paper examines the verification of our prototype and its concept in a real hospital environment. More specifically, The following concepts are discussed: (1) a dynamics simulation model, based on several interviews conducted with the health care professionals who are currently working for well respected Boston-based medical institutions; (2) an analysis of the model is presented along with the model boundary, characteristics of the model behavior, and assumptions made; (3) desirable features for integrated health care information system, which reflects some real needs we obtained through interviews and model analysis; (4) a comparison between those desirable features and actual features that our prototype is currently providing, along with thoughts regarding future improvements of the system.

1.4 Methodology

In order in order to verify the degree of compliance of the prototype in comparison to the reality, a system dynamics simulation model has been developed. System Dynamics is an effective tool to understand the complex world around us. It has been applied to a wide variety of challenging cases in politics, social science, business management, literature, and engineering.

One of the underlying premises of system dynamics is to see the world as a chain of events that causes changes in other parts of the system rather than just a linear progression of disjointed, single events.

In the past, works related to infection disease and insurance have been done using the system dynamics approach to gain a better understanding of the issues in the health care industry.

1.5 Thesis Organization

In order to present the idea of this thesis effectively, the structure of the simulation is discussed first. Following that, an analysis of the model structure, model behavior and limitation of the model is performed. Next, future improvement to the model is listed. Finally, the verification and the future improvement of our prototype based on insights acquired through the simulation are discussed.

Chapter2 -Introduction of the Methodology

2.1 Introduction of System Dynamics

System dynamics is a field of study, founded by Jay Forrester in 1956 at Sloan School of Management, Massachusetts Institute of Technology, for studying and managing complex feedback systems, such as one finds in business and other social systems.

What system dynamics attempts to do is to understand the basic structure of a complex system and the behavior it can produce. Many of these systems and the problems that they created can be built as a computer model, and those models are often used for developing effective policies, strategies and solutions for problems.

System dynamics takes a different approach from other approaches to study complex systems in social, political, business and many other issues. That approach is the use of feedback loops. Combination of causal loop diagram and stocks and flows diagrams – both are core components of system dynamics – help to describe how systems are connected each other by feedback loops, which create the nonlinearity that we frequently find in modern day problems.

Following, I will describe some of the important concepts and terms that are used in system dynamics.

2.1.1 System Thinking

System thinking is a core component of system dynamics. The approach of system thinking is fundamentally different from that of traditional forms of analysis. Traditional analysis mainly focuses on separating smaller individual pieces of the system and analyzes each characteristic. System thinking, in contrast, looks at things as a whole, and focuses on how one constituent interacts with other constituents of the system. In other words, system thinking deals with the interactions among parts of the system, which enables us to understand how the entire system behaves as a result.

On the contrary, traditional methods deal with a part of the system and analyze its function, structure and characteristics. This difference in system thinking results sometimes in strikingly different conclusions than those generated by traditional forms of analysis, especially when the subject is dynamically complex.

2.1.2 Causal Loop and Feedback loop

Feedback is another important concept in system dynamics. Feedback loops consists of closed paths of cause and effect. Loops can be categorized into two types: one is positive feedback, and the other is negative feedback loop. Positive loops are known as self-enforcing loops. In Figure2.1, I present a simple example of a re-enforcement or positive loop. The diagram is constructed by two variables and two links. The logical connection for this diagram is following: as the number of chickens increases the number of eggs increases. In the same way, the number of eggs increases then the number of chickens increases. Therefore, repetition of this cycle generates an exponential growth in the population of chickens and eggs, as shown in Figure2.1.

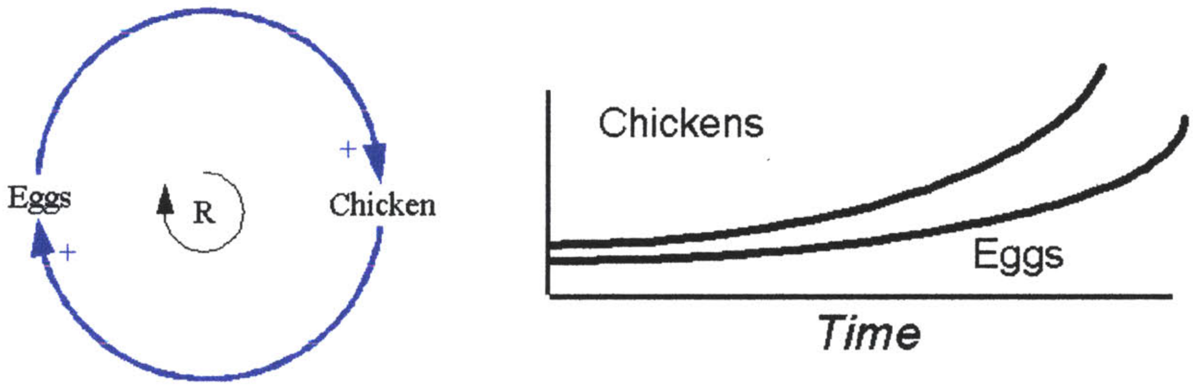


Figure 2.1 Example of positive loop by Sterman, J.

Negative loops are self-correcting. Figure2.2 shows an example of a negative loop. The logical connection for this diagram is that as the number of chickens increases, the number of road crossings of the chickens increases. However, as the number of crossings increase, the number of chickens killed by accident also increases. This eventually reduces the population of chickens over time. Therefore, the outcome of this loop should look like goal seeking behavior as presented graph in Figure 2.2.

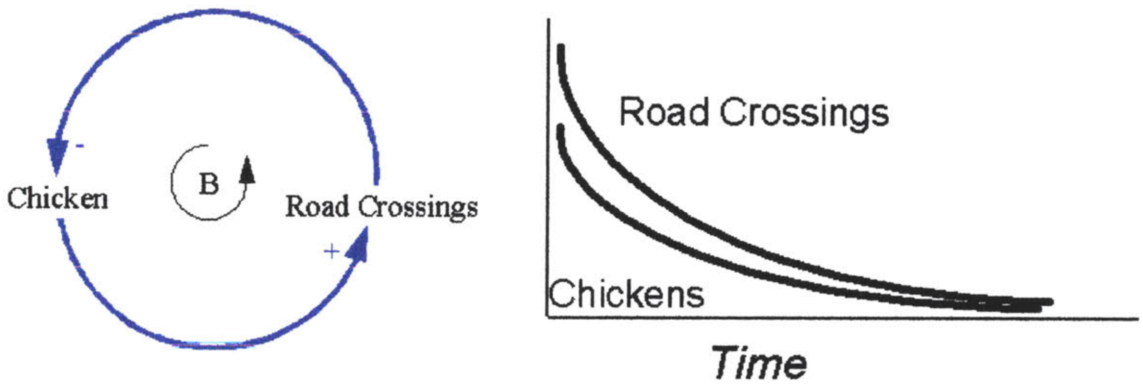


Figure 2.2 Example of negative loop by Sterman, J.

Thus, the interaction of these two loops creates dynamics behavior which would look like Figure2.3. Figure2.3 is an example of multiple loops. The diagram is the combination of loops in Figure2.1 and 2.2. Three graphs presented in Figure2.3 are the example of some of the expected behaviors that this combination of two loops could generate. The difference in the shape of the graph is caused because of the difference in the strength of the loops. In other words, the loop or loops, that is the strongest at any given time will temporally dominate the system and define the shape of the graph. Therefore, we cannot identify which one of these will possibly be the outcome of this system at this time.

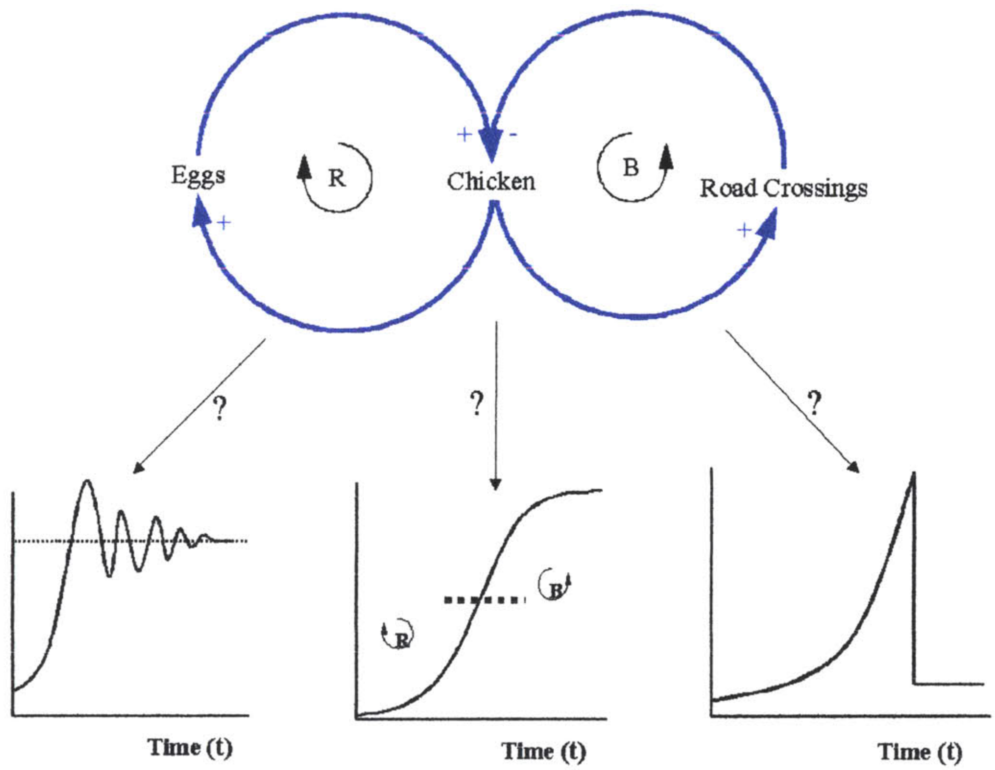


Figure 2.3 Example of multiple loop by Sterman, J.

As I have shown above, causal loop diagrams are simple maps showing the causal links among variables with arrows from a cause to an effect. This causal loop diagram consists of three elements. These elements are variables, links, and polarity. Variables are the elements of the system. Such examples are Chicken and Egg in Figure2.3. Links are the connection of those variables. The nature of the relationships between two variables is represented by polarity, either a positive (+) or negative (-) signature.

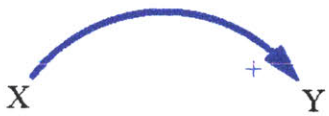
Symbol	Interpretation
	All else equal, if X increases (decreases), then Y increases (decreases) above(below) what it would have been.Incase of accumulation s, X adds to Y.
	All else equal, if X decrease (increases), then Y decreases (increase) below (above) what it would have been.Incase of accumulation s, X subtracts from Y.

Figure 2.4 Polarity and Links by Sterman, J

2.1.3 Stock and Flow Structure

There are some limitations in causal loop diagrams, although a causal loop diagram is a friendly and useful tool to represent interdependencies and feed-back processes. One of the most important limitations of causal diagrams is their inability to capture the stock and flow structure of the system. Stocks are accumulations, and the level of accumulation in the stock is controlled by flows, both inflows and out flows. Stocks are important because stocks generate delays that cause dynamics in behavior of the system.

Stock and flow, along with feedback, are two central concepts of dynamic system theory.

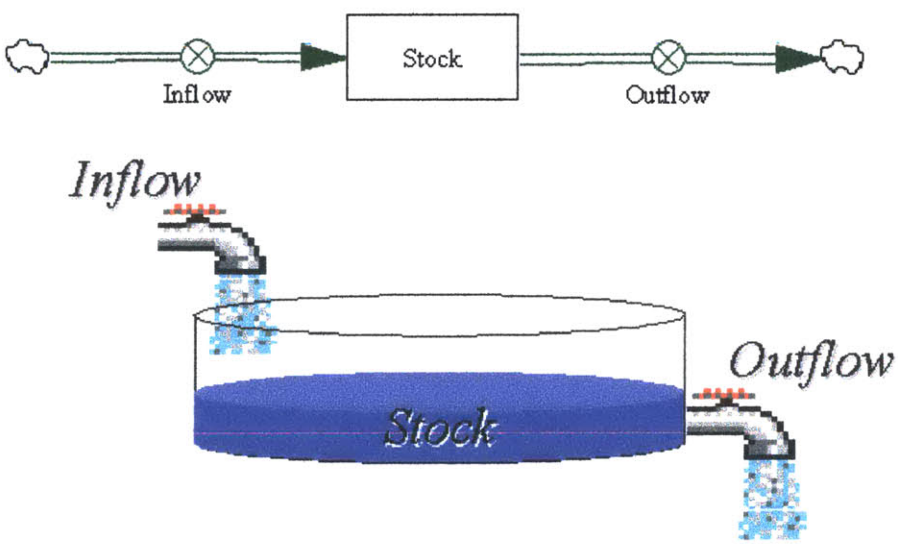


Figure 2.5 Sock and Flow Structure Example

2.2 Benefit of System Dynamics

There are many benefits of using system dynamics. It can be a very powerful and useful tool to deal with complex issues in many levels. For example, a causal loop diagram is particularly useful because it is a very explicit and intuitive tool. It can be used as a tool for sharing our mental models with others and help us in unifying knowledge on issues.

System dynamics also help us to enhance our mental model. We usually make assumptions and simplify issues to understand them better in the own way.

However, these assumptions sometimes make difficult for us to share ideas. System dynamics is helpful to clarify such underling assumptions and enhance the boundary of our mental model. Those implicit assumptions are often elicited and clarified through the process of developing causal loop diagrams.

Among many benefits, probably the most valuable contribution of system dynamics is allowing us to use the richest source of information that we can afford, i.e., mental database, to build effective policies and solutions.

The process of changing data format from mental data to written data, and written data to numerical data diminish the richness of information, which is often reflected in one's insights. The system dynamic's approach overcame this problem by introducing own framework and methodology that allow them to directly access to the mental database. This advantage of using mental database becomes even more significant since it is the most effective strategy to make a transit in paradigm.

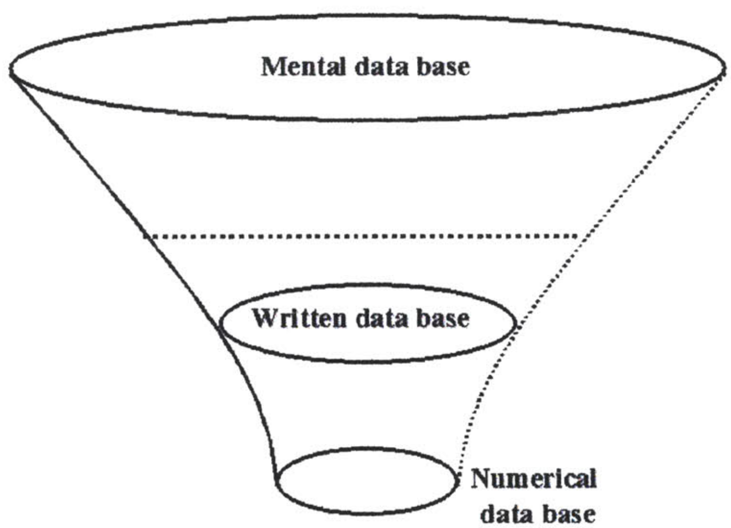


Figure 2.6 Decreasing information content in moving from mental to written to numerical database by Forrester, J

Chapter3 – Dynamic Simulation Modeling

3.1 Overview of modeling process

During the last eight months, I was privileged to be able to interview physicians, nurses, hospital administrators, faculty members of medical schools, health care system vendors, and health care consultants. Through these interviews, I tried to understand the essence of the issues and challenges with which they are currently struggling, and to find the direction where this industry is headed. In this and the following chapter, I will present a simulation model that my colleague and I developed. This model is based on interviews my colleague and I conducted. Our intention for building a simulation model is to replicate some of the behaviors that we can observe in the real health care industry in the United States, and analyze that model to gain a better understanding of the industry. However, since the health care industry is a large and complex system, it is impossible for us to capture its many aspects and entities.

For this reason, we decided to focus on the most dominant opinion among health care professionals, which we identified through interviews, and kept the model boundary smaller in order to keep the simulation within a manageable size. To build this simulation model, we used *Vensim©*. First, I will introduce some dynamics hypothesis - patterns of expected behaviors of the key variables - that we obtained through interviews. Then, I will move on to introduce a model structure.

3.2 Introduction of Dynamics Hypotheses

As I described in the previous section, health care is a large and complicated system. It involves many actors and aspects. Through interviews that we conducted with physicians, nurses, hospital administrators, health care information system vendors, and consultants who work in health care industry, we were able to identify many different types of issues that the health care industry is currently facing. Those issues reflect some of the important dynamic behaviors which exists in this industry. Following, I will present a list of subjects that people in the industry are interested in and for which they have particular concern. I add a brief explanation of each issue.

- **Increasing number of patients**
  - As the aging society progresses, the number of people who need medical attention increases significantly.

- **Increasing cost in health care.**
  - Insurance premium has been increasing sharply in the last ten yeas as the total cost for medical service has increased, corresponding to the progress of the aging society.

- **Increasing patient's consumerism**

  - As patients became more knowledgeable about their conditions and diseases, they tried to participate in the process of decision-making. This participation for decision-making made patients more knowledgeable through their increased interaction with physicians. As a result, there relationship between physicians and patients also become more active.

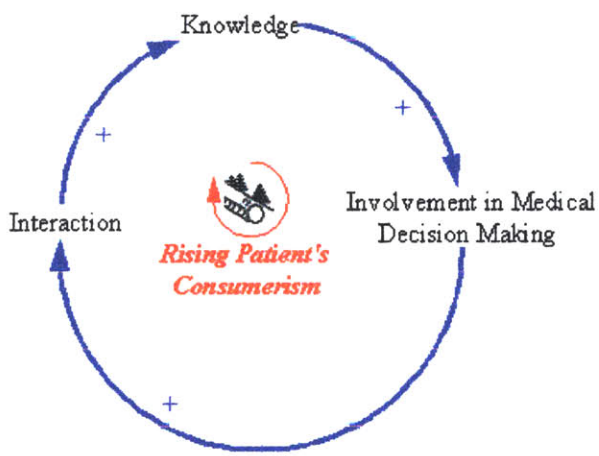


Figure 3.1 Rising Patient's consumerism

- **Finance structure of health care industry**

    - Government and private insurance companies provide hospital primary financial sources. Hospitals receive money, which is allocated according to specific guidelines by the insurance contracts. Hospital financing is currently constrained by the framework of capitation, which has been primal system in insurance industry for a long time. The capitation system defines two things, (1) how much money can the hospital get from insurance companies per patient, and (2) how many patients' hospital needs require attention.

        - In the following section is a very brief summary of a typical capitation contract between a hospital and HMOs. " Up to 100 patients, we pay you 50 dollars per patients. However, even if you exceed 100 patients, I will not pay more than 5,000 dollars, which is equilibrium amount of 100 patients times 50 dollars per patient.

    The capitation system exerts an enormous amount of financial pressure on hospitals. Hospitals have an ethical obligation to see patients if they require medical attention. However, an excessive number of patients creates serious financial trouble for a hospital. Thus, hospitals, naturally, try to optimize their operation by cutting unnecessary treatment to patients. They rather choose to provide financially but not technically suitable due to the patient's health care plan.

In order to resolve this issue, some hospitals started to use a service based charging system, i.e., the amount of money the hospital can get is based on the service provided. The adoption of this new system seems to be supported not only by the hospital but also by the patients who are involved in increasing their consumerism.

- **Issue of overwork for physicians and nurses**
  - An increase in the number of patients develops a tremendous amount of overwork for the physicians, nurses, laboratory technicians and other members of the caregiver team.

- **Quality of medical service issue**
  - Increasing work pressure develops a negative influence on the quality of service, which is often visible in the rate of mistakes accumulated and the time required to finish each assigned task.

- **Competition**
  - Each practitioner would like to be the best in the field because excellent performance makes them influential in the health care organization and allows them to make a great deal of money. On the other hand, this sense of rivalry can be used to introduce new technologies. For instance, if a successful implementation of the new technology boosted the reputation of one particular doctor, other doctors, in order not to be surpassed, may be attracted to using the technology. This helps to spread the value of that particular technology, as well as raising the reputation of the hospital in a very competitive field.

- **Reputation of health care organization issue**
    - Reputation is one of the useful indicators for hospitals to understand how well they are doing from their patients' point of view. The reputation of a hospital can be classified in two types. One is the type of reputation driven by an excellent doctor, and the other is based on total performance of the hospital in general. However, it is not always clear which of these reputations is the stronger, nor is it easy to measure the impact of the combined reputations.

- **Authority issue**
    - Many hospitals are more likely to depend on one doctor or a small group of doctors' performances and reputations. The fame of these doctors empowers these particular doctors and the hospital risks losing its authority. This kind of shift in power can often be seen in budget control. Today, a department head has more control on how to spend his or her budget than hospital management. Further,

the tendency of each field becoming more specialized also contributes to the transfer of decision making authority and budget control from hospital management to department head level.

- **Tradition vs new method issue**

  - Physicians have practiced in their own way over decades, going through the same processes and routines of making a diagnosis by writing it out on paper. One of the reasons why it is difficult to introduce a new technology into medical practice is because of similar, routinized work habits.

    For example, in the case of electronic patient records, from a physician's point of view, there is no difference in function whether writing a note on paper or typing on a PC, since both provide exactly the same functions and data which they used for making a diagnosis. Therefore, physicians are more likely to stay with method with which they are familiar. For the successful introduction of the new technology, it is critical to overcome this kind of lock-in thinking.

- **Issue of identifying leading user**
  - For the successful implementation of new technologies, it is important to satisfy two requirements. First, the new technology should fit into the existing physicians' process flow. It is not likely to be adopted when technology does not fit into this existing workflow, even if that technology were superior.

    Second, to identify the appropriate primary users. This is very impermanent because we often fail to identify them accurately because of misunderstanding the system. For example, people often assume that doctors are the primary users of health care and actually input patient data into the system. However, in reality nurses are most likely to be in charge of data input, while physicians remain as the primary users of such information. Therefore, it is important to get support from nurses.

- **Adoption of technology and technology learning curve**
  - The Learning curve is a serious issue for physicians. They have tried many prototype systems that were brought by vendors. However, most of these vendors could not survive in competition and they stopped supporting the system after few months. As a result, doctors wasted their time trying to learn how to use a new system. Because many frequently experienced this problem, doctors were discouraged from trying out new systems that require some months to learn. It usually takes six months for a nurse to learn how a new system and technology works, while it usually takes much longer for doctors.

- **Time sensitiveness and convenience factor influence on use of IT**
  - Caregivers are very time sensitive people. One of the reasons why patients are asked exactly the same questions over and over again when they are admitted to a hospital is not because they do not have those data in the patient's record, but rather because it is easer to interview patients directly than to look up their

records.

To resolve this concern, hospital has tried to adopt information technology. Such a technology is not yet convenient enough to improve their work habits because many databases in the hospital have not been integrated.

- **Doctors maturing rate and hospital capacity issue**
    - It is important for hospitals to control the level of maturity of physicians and nurses to maximize hospital capability. In order for inexperienced doctors to polish their skills, they need to get sufficient experience. Today, in a tolerant environment, such as a teaching hospital, inexperienced doctors are allowed to make minor mistakes in order to learn from them. In contrast, in an environment where making a mistake is not an option, such as in an Emergency Room, physicians are instructed to follow strict protocols and guidelines, and inexperienced physicians gain experience while following those protocols.

- **Nurse helps to improve doctors' performance**
  - Another way for inexperienced physicians to gain experience and necessary knowledge is learning from nurses. Nurses are a great source of information for two reasons. For example, they are the ones who actually take care of patients on daily bases. Also, nurses are often more familiar with the hospital system than doctors. In order to exchange their experiences, perspectives and information, currently, nurses spend time one-on-one with physicians. These meetings help physicians both in developing intimate working relationships and obtaining necessary information.

3.3 Introduction of basic structure of health care industry

As I illustrated in the previous section, the health care issue is a large complicated system, and it is impossible for us to capture every issue in one small simulation model. Therefore, my colleague and I focused on one particular aspect of the issue, which may reflect interesting results and one of the major issues in today's health care industry.

Figure 3.2 is a causal loop diagram for our simulation. This represents a very simplified version of the aspect of the industry, which we are trying to capture. This aggregated diagram contains four important loop sets, two re-enforcement loops and two balancing loops. Those four loops are *Quality of Service Loop, Reputation With Quality Service Loop, Reputation With Experience Loop, and Care Team Capacity Expansion Loop.* Following, I will describe detail of each loop.

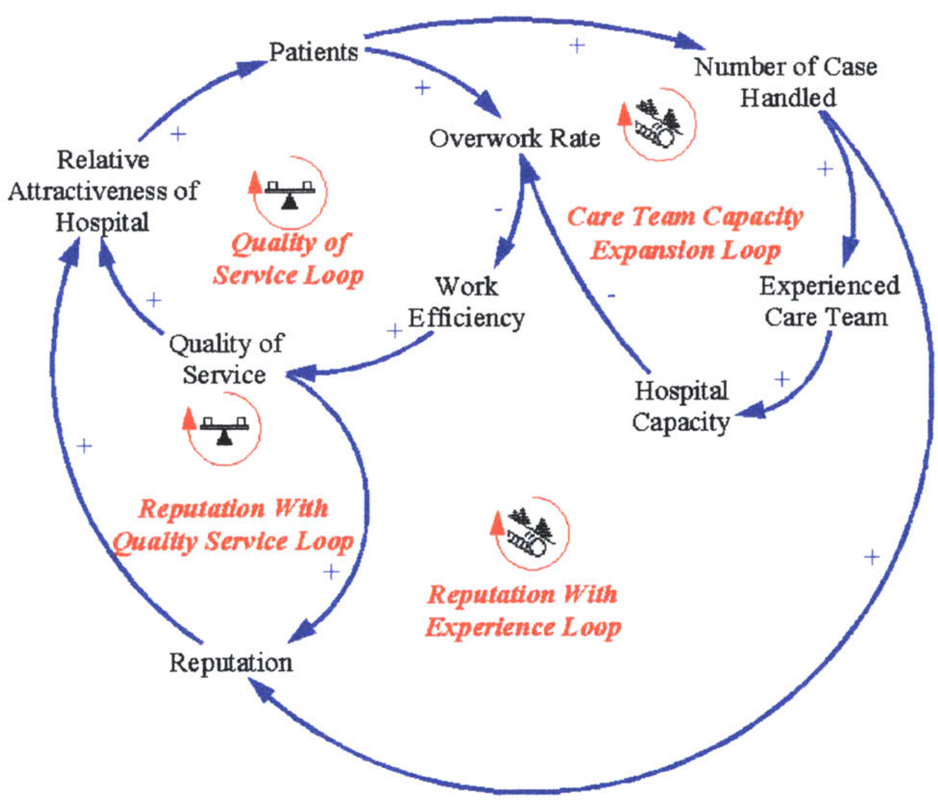


Figure 3.2 Causal Loop Diagram for Hospital Patient Flow

3.4 Segmentations

I will introduce the basic logic for each of four loops -*Quality of Service Loop, Reputation With Quality Service Loop, Reputation With Experience Loop, and Care Team Capacity Expansion Loop*- following.

3.4.1 Quality of Service Loop

Figure3.3 represents Quality of Service for the hospital. This is the base loop for our model. We introduced five variables here. They are: (1) *Patients,* (2) *Overwork Rate,* (3) *Work Efficiency,* (4) *Quality of Service,* and (5) *Relative Attractiveness of Hospital.* The logic for this loop is seen in the fact that as the number of patients increase, *Overwork Rate* increases. As a result, *Quality of Service* is diminished corresponding to decreasing *Work Efficiency*. Thus, the *Relative Attractiveness of Hospital* decreases, and this attracts fewer new patients. This loop is a balancing loop.

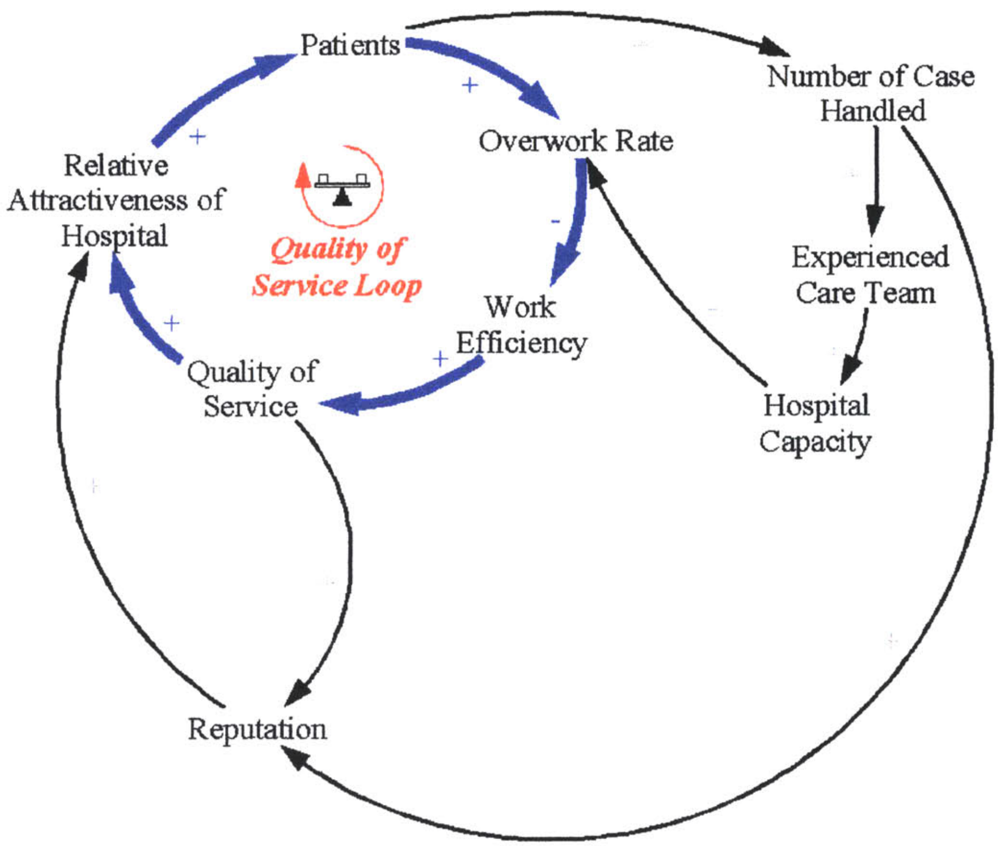


Figure 3.3 Diagram for Quality of Service Loop Set

3.4.2 Reputation With Quality Service Loop

Figure3.4 represents how the quality of service the hospital provides affects the hospital's reputation. In this loop, we introduced an additional variable, *Reputation*, to the *Quality of Service Loop*, which I described in the previous section. This loop is also a balancing loop. The basic logic for this loop is that better quality of service results in a good reputation. This good reputation contributes to increase the relative attractiveness of the hospital. However, an increasing number of patients eventually kills the quality of service due to overwork.

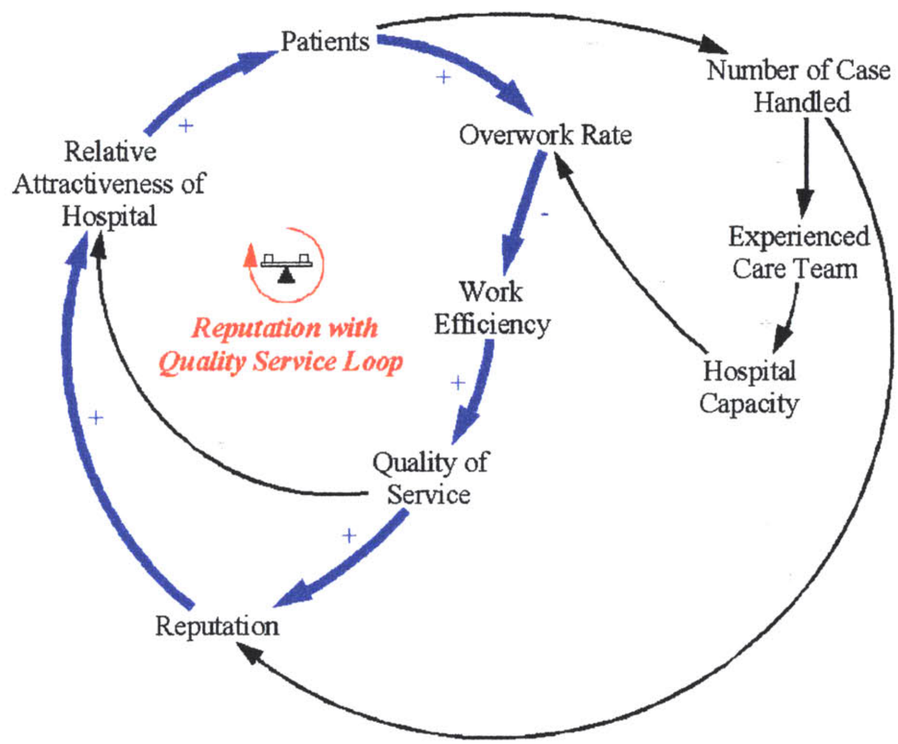


Figure 3.4 Diagram for Reputation With Quality of Service Loop Set

3.4.3 Reputation With Experience Loop

Figure3.5 represents how the number of cases that the hospital handles affects its reputation. We introduced another variable, *Number of Cases Handled.* We tried to capture two things: (1) how the number of visible cases, or high profile cases, attract more potential patients, and (2) how the level of maturity of physicians affects a hospital's reputation. We believed that both of these inputs generate a positive reputation for the hospital. Thus, number of new patients is increased as the number of successful cases increases a good reputation. This loop is a positive feedback loop.

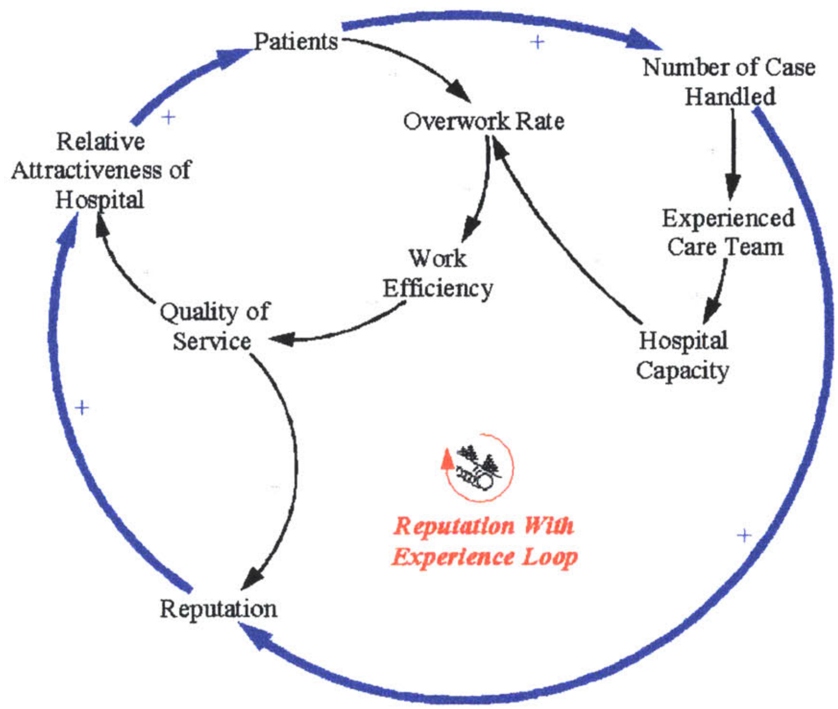


Figure 3.5 Diagram for Reputation With Experience Loop Set

3.4.4 Care Team Capacity Expansion Loop

Figure3.6 represents how the hospital capacity is built and expanded. Here, we introduced two new variables, *Experienced Care Team* and *Hospital Capacity.* This is also a positive loop. However, this loop is more complex than the previous one because it involves a time delay between *Number of Case Handled* and *Experienced Care Team.* This delay means that there is no way to increase the number of doctors overnight. Education for becoming a doctor takes a long time, and gaining sufficient experience takes even longer.

Therefore, as the number of patients increases, the number of cases handled increases. The doctors' skill level is improved with a time delay as they experience more cases. Once the number of experienced doctors increase, hospital capacity is expanded. This decreases *Overwork Rate* for physicians. As a result, *Quality of Service* is improved. This results in attracting more patients to the hospital.

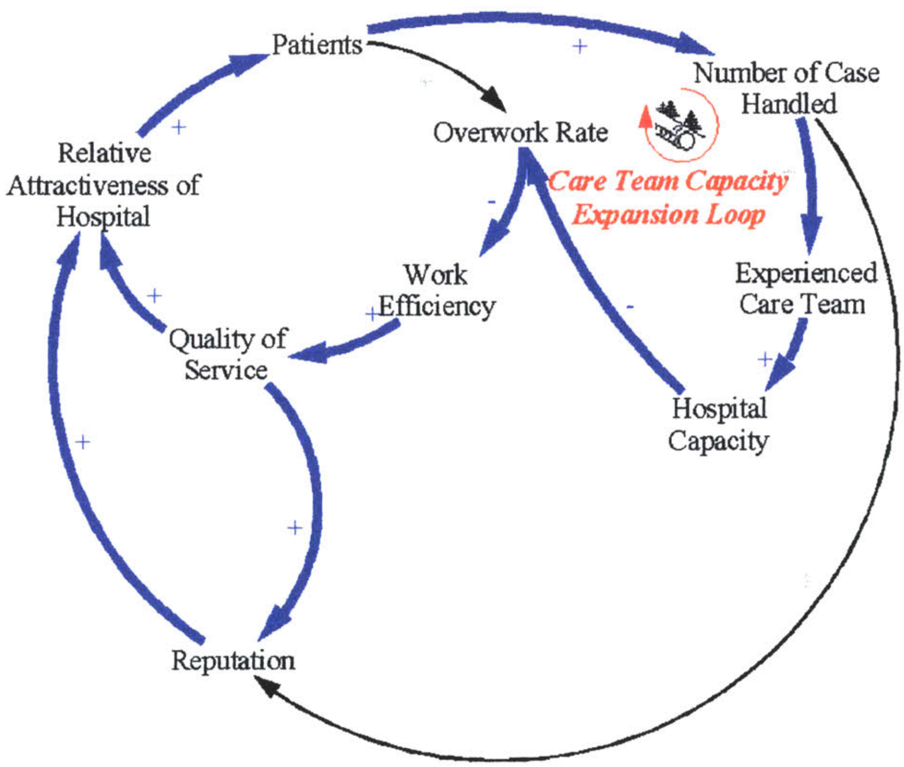


Figure 3.6 Diagram for Care Team Capacity Expansion Loop

3.5 Causal Loop Diagram With Stock

Causal loop diagram presented as Figure3.2 was appropriate for presenting key logical connections among variables. However, that diagram did not capture a certain type of important information such as stocks and flows.

In Figure3.7, we presented a new diagram that is improved from a previous diagram (Figure3.2). We identified some of the important stocks in this new diagram. We introduced five stocks in total. They are *Patients, Number of Case Handled, Doctors, Nurses, and Reputation.* Identifying these stocks are one of the important processes because these stocks are the source of delays and generate some dynamic behavior from this system.

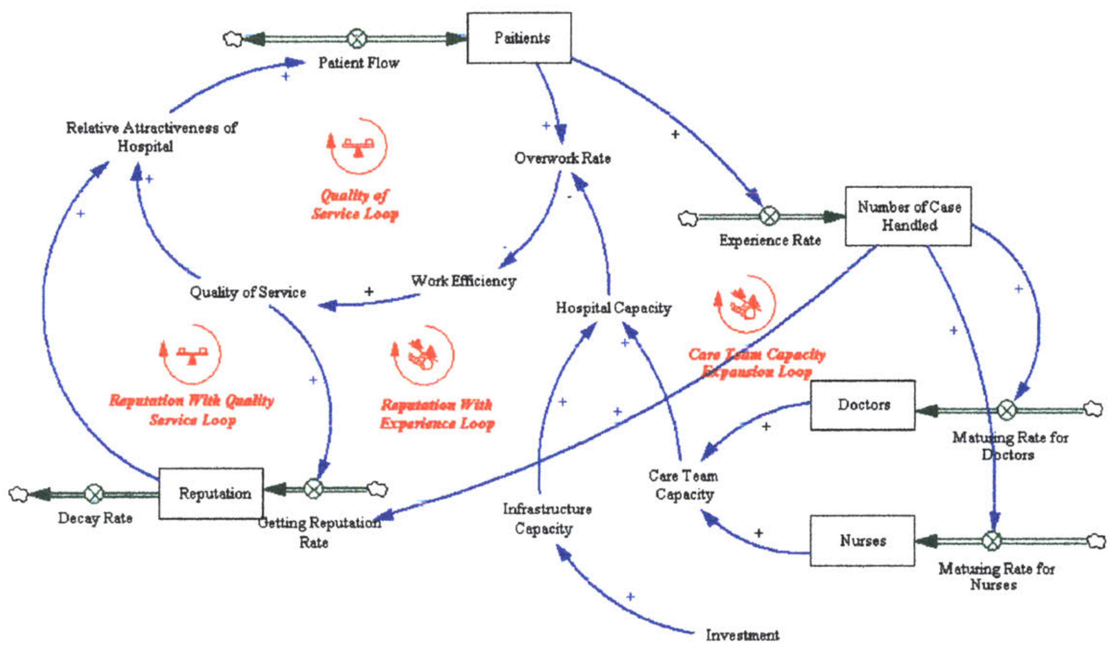


Figure 3.7 Diagram for Hospital Patient Flow with Stocks

3.6 Introduction of the Model

In order to convert a causal loop diagram (Figure3.7) into a simulation model, we narrowed down the scope of the issue and concentrated on the following essential hypothesis.

- *Patients* are the main stock of the system.

- *Overwork Rate* controls *Quality of Service.*

- *Hospital Capacity* is defined by number of experienced physicians.

Based on the three points listed above, we developed a simulation model, which is displayed as Figure3.8. In order to build this model, we used Widget Model (Chapter 18 of *Business Dynamics, Sterman, J.*) as a reference.

In the following chapter, I will discuss details of this simulation model.

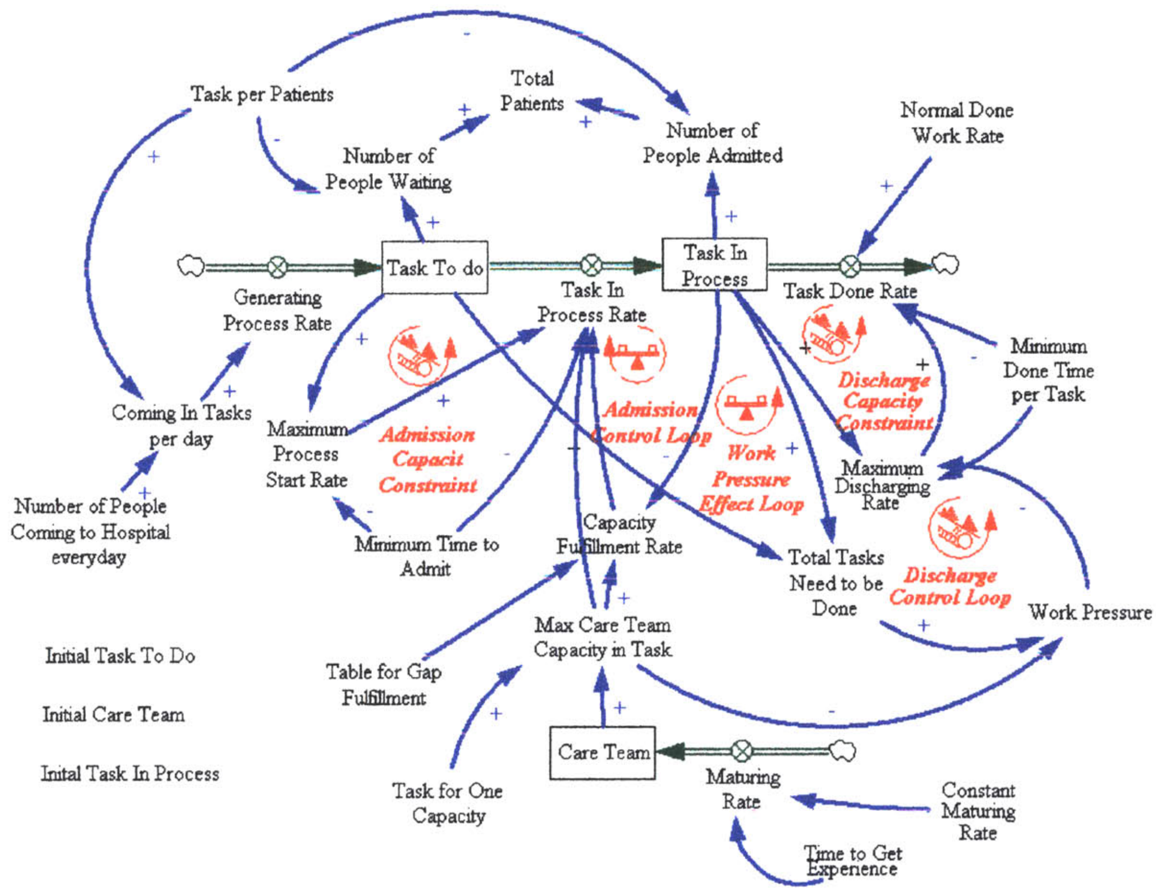


Figure 3.8 Hospital Patients Flow Simulation Model

Chapter4 – Analysis of the Simulation

4.1 Details and Characteristics of the Simulation Model

In order to successfully convert the loops -*Quality of Service Loop, Reputation With Quality Service Loop, Reputation With Experience Loop, and Care Team Capacity Expansion Loop*- into an operational simulation, we came up with the following ideas.

4.1.1 Stock Structure

The first challenge that we faced was the representation of the amount of work in a hospital. Initially, we set the main stock as *Patients* and *Admitted Patients* (Figure4.1). It was natural for us to think of setting these two as the main stock. However, as we developed the rest of the simulation, we realized the difficulty in trying to capture the level of hospital work based on the number of the patients without considering other factors. For instance, the level of a hospital workload seems to be defined by the number of tasks performed rather than the number of patients. Therefore, we decided to use tasks for the main stocks instead of patients as shown in Figure4.1.

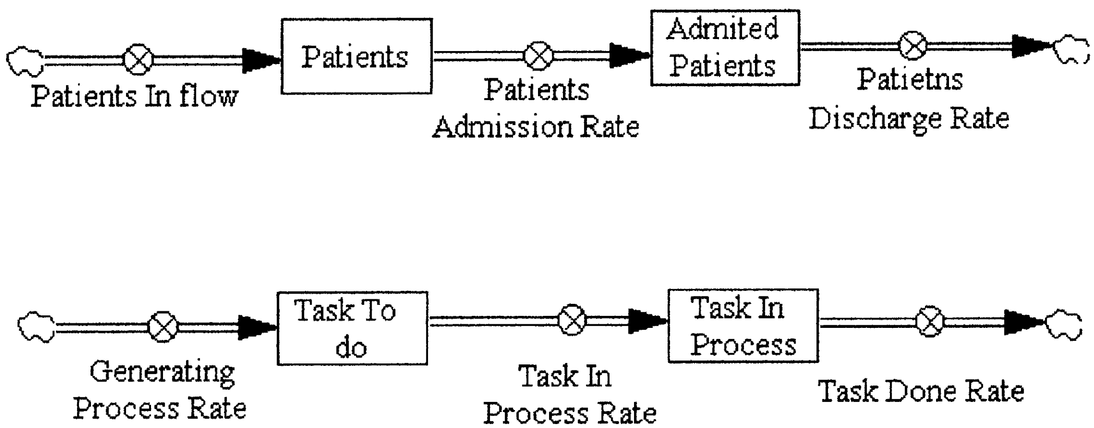


Figure 4.1 Comparison between Patients Flow and Task Flow Structure

4.1.2 Convert Tasks into Patients

Although we did not treat patients as the main stock, it is still a very important variable. In fact, "patients" is still a unit that is the most often used in any medical institution to measure hospital capacity. Therefore, we came up with the solution of converting the number of the tasks into the number of patients. Figure4.2 is the component that allows this conversion in numbers.

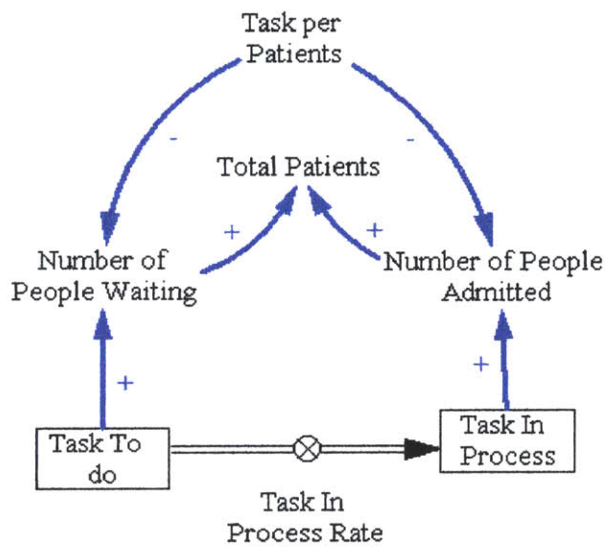


Figure 4.2 Calculating total patient numbers from number of tasks

4.1.3 Admission Control Structure

To control *Task in Process Rate* is one of the other important components of this simulation.

There are two important basic objectives that this component needs to accomplish. One is that *Task To do* not generate negative value since such concept does not exist in the real world. Another is to accept no more patients than capacity, defined by the number of people that physicians can take care of. To achieve this, we introduce *Capacity Fulfillment*

Rate, which is the ratio of *Task in Process* and *Max Care Team Capacity in Task.*. This fulfillment rate controls the number of newly admitted patients based on its current vacant capacity.

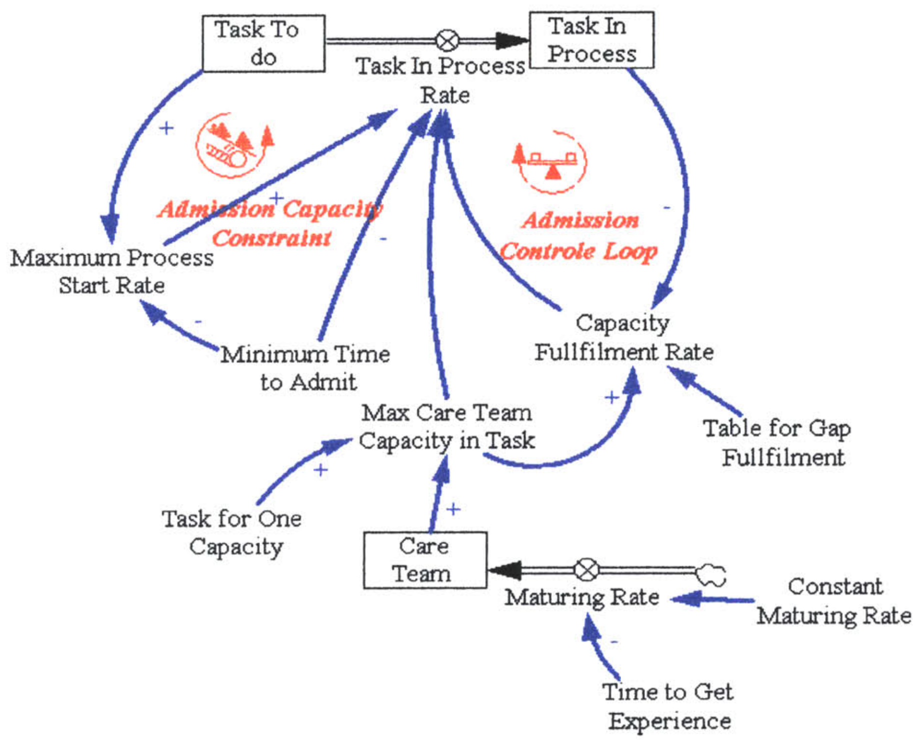


Figure 4.3 Admission Rate Control Components

4.1.4 Discharging Control Structure

Controlling discharge rate is another important task. We developed a component which controls this flow by using the level of *Work Pressure*. There were two ideas that we wanted to implement here. The first idea was the representation of work pressure. We defined that the total tasks that *Care Team* has to do is the sum of *Task to do* and *Task In Process*. We took the ratio of this number, the sum of two values, and hospital capacity and named that *Work Pressure*. This means that not only admitting more patients, but also having more queuing patients is generating more work pressure.

The second idea is how this work pressure influences discharging rate, *Task Done Rate*. In our model, *Task Done Rate* will decline when *Work Pressure* increases. The basic logic for this follows: Once the work pressure goes up, there results decreased efficiency in the work. Thus, more time is required to finish for task. As a result, the *Task Done Rate* will decline, causing fewer discharges of patients.

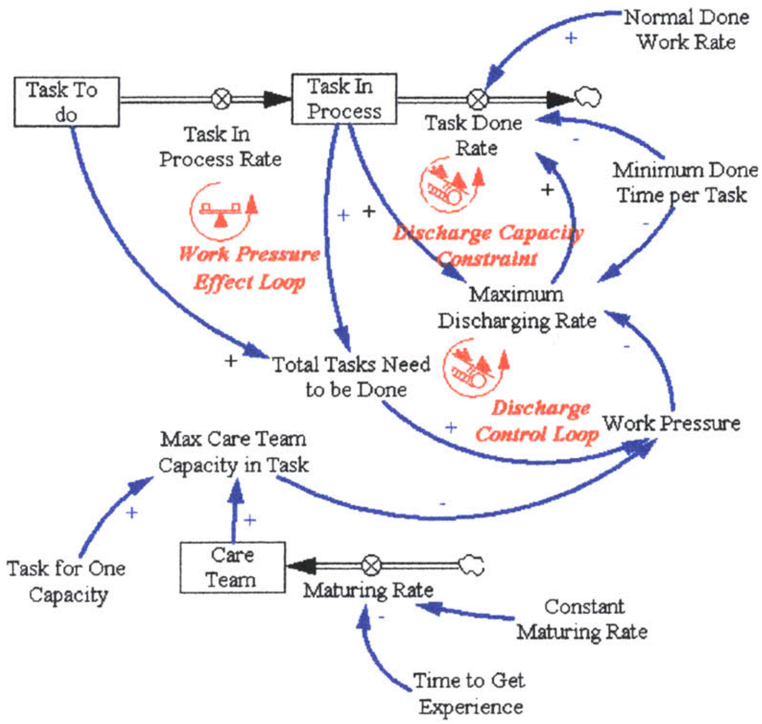


Figure 4.4 Discharge Rate Control Component

4.1.5 Care Team

In reality, hospital capacity is the function of physicians, nurses, and equipment. Moreover, physicians and nurses, who are the stocks, can be divided into two different types: experienced and inexperienced. However, we simplified this mode as Figure 4.5.

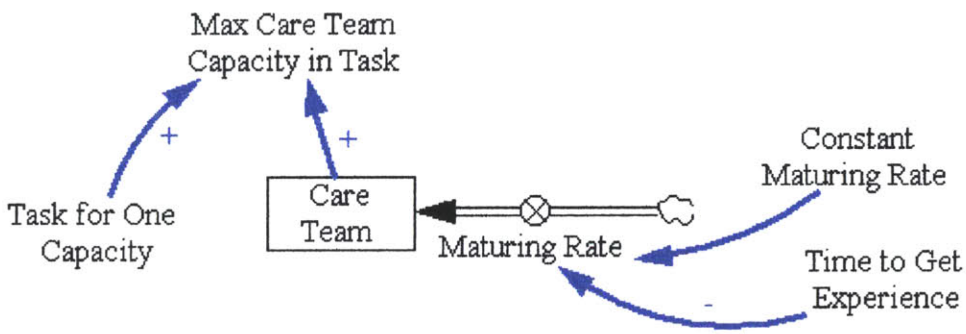


Figure 4.5 Care Team Stock Structure

4.2 Simulation Results

In the following sections, I will write about the result of our simulation run. In the beginning, I will introduce our simulation model and its initial conditions. Figure4.6 and 4.7 are screenshots from the simulation of Vensim© DSS. Figure4.6 is the simulation itself. Figure4.7 is its output graphs. The following shows the value for variables of the base run simulation:

- Task per patients = 5 tasks
- Number of people coming to hospital every day = 100 people
- Initial task to do =1000 tasks
- Initial care team = 23.5 team
- Initial Task in Process = 0 task
- Minimum Time to Admit = 0.25 day
- Task for one capacity = 5 tasks per team
- Time to get experience = 180 days
- Constant Maturing rate =5 teams
- Minimum Dome Time Per Task = 0.5 day
- Normal done Work Rate = 3 tasks per day
- Simulation Time = 30 days

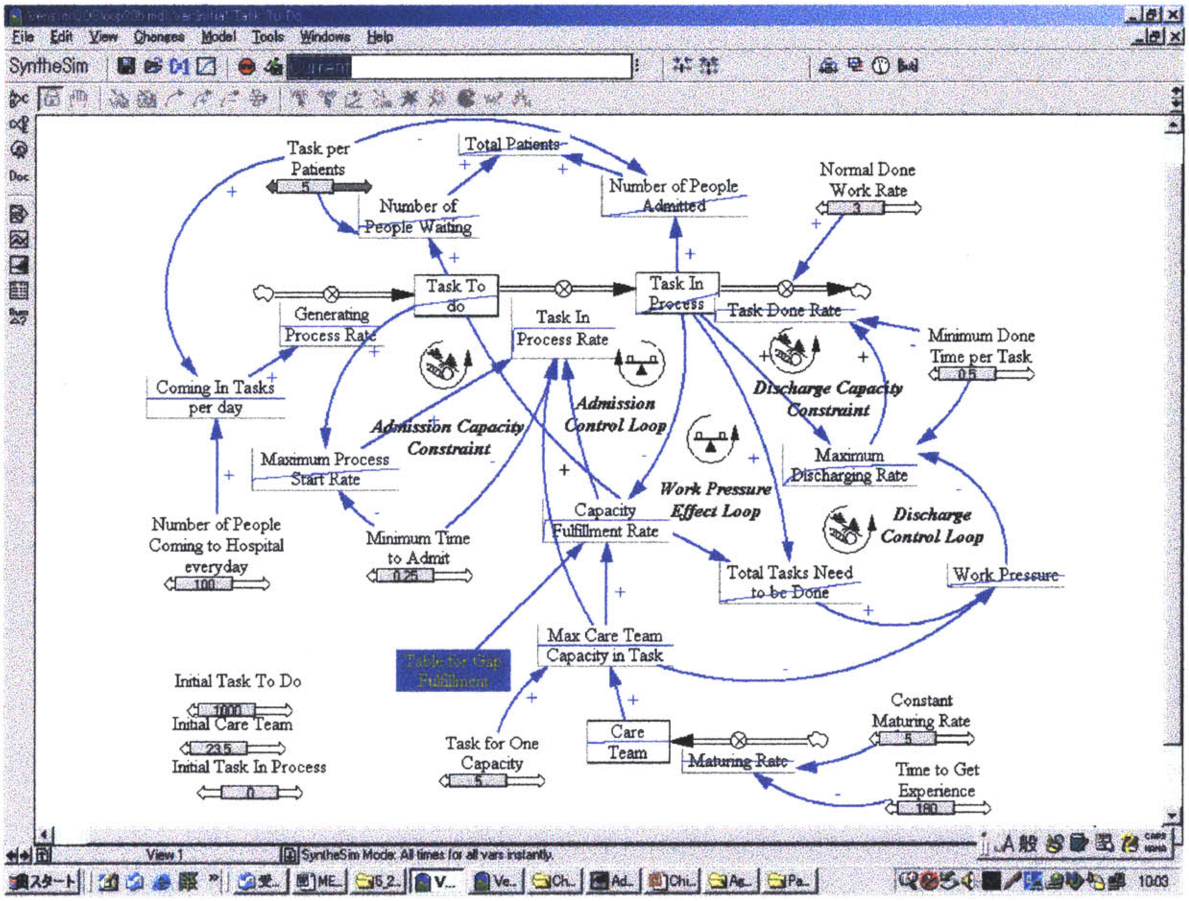


Figure 4.6 Vensim© DSS Simulation Screen

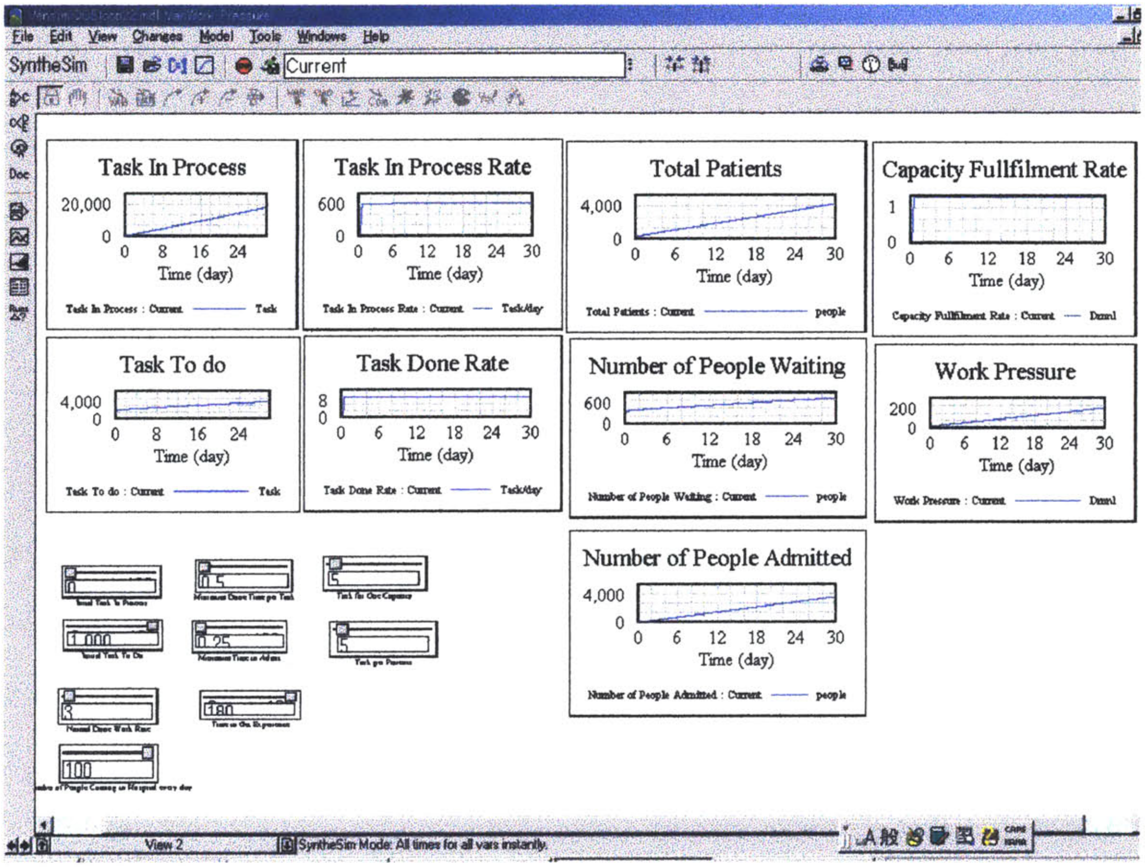


Figure 4.7 Aggregated Output Screen on Vensim© DSS

4.3 Summary of System Sensitivity Test

I conducted several simulation runs and identified the most influential variable in the system. The primary purpose of checking the sensitivity of the system for each input is to find effective solutions for the problem that the system created. Through these simulation runs, we discovered some interesting behaviors.

I will briefly summarize those results:

- **Minimum time to Admit**
  - Increase in value for this variable generates longer time delay for the entire system. *Task In Process Rate*, *Task Done Rate*, *Capacity Fulfillment Rate*, and *Maximum Discharging Rat*e shows less steeper S-shape growth.

- **Initial Care Team**
  - This value represents the number of care teams available at the starting point of the simulation. Increase in this number generates overshooting behavior in *Task To do* and *Task in Process Rate*. However, it does not provide significant impact on *Task In Process* and *Task Done Rate*. Basically, what is happening here is eating up the pending demand because the initial capacity is so large.

- **Task for One Capacity**
  - This represents the number of tasks that one team can handle. This variable can generate some change in behavior for *Task To Do* and *Task In Process Rate*. Essentially, this has similar impact as *Initial Care Team* has.

- **Constant Maturing Rate**
  - This value represents how many care teams are generated. This value can generate an arch similar to the shape for *Task To Do*. Increase in this value also generates less work pressure and enlarges *Maximum Discharge Rate*

4.4 Model Boundary and Assumptions

Any simulation model has a boundary and a limitation. Understanding these constraints, including the assumptions we made for simplifying the reality, is a very important process of the model analysis. Here I will briefly summarize and discuss the constraints of the model.

- **Constant growth rate for *Generating Process Rate***
    - We set this as a constant for two reasons. First, people visit a hospital whenever they feel sick whether they are actually sick or not. People do this because they need to hear professional opinions from doctors to feel better. Second, recent statistics show that the number of patients has been increasing significantly. We wanted to reflect these two phenomena. Therefore, we set this value as a constant.

- **No Financial Segments**
    - Financial structures are different in each health care organization. In order to build a concrete model to capture this, we need to build a complicated set of loops. Because of the amount of work required to accomplish this model, we will postpone it presentation.

- **Simplified Capacity component**
    - To represent hospital capacity, we used *Care Team* as stock. However, capacity should be represented by the combination of doctors, nurses, laboratory technicians, and equipment. Also, it is important to differentiate each player according to the level of experience and level of performance since there are significant gaps between those who are considered the best and those who considered the worst.

- **No rework**
    - Currently, there is no flow that represents rework. In order to keep the simulation at a manageable size, we decided to omit this for time being.

- **No priority on patients' condition**
  - There is no indicator that prioritizes patients according to their conditions. Because this is a very critical component of this system and requires a fundamental change in structure, we decided not to include it at this point.

4.5 Insights

The following is a list of insights derived from running the model simulation.

- One of the basic components in our model is the stock "task". While on the surface it would seem natural to track workflow inside a hospital in terms of patients, based on actual interviews conducted during our research this is actually not the best way to represent workflow. Hospital workload is best defined by the number of tasks that need to be performed, with patients being the main sources of those tasks. This implies that the concept of patient population can be characterized by aggregate tasks. Each patient has to go through a sequence of steps while in hospital - examination, education of the diseases the patient has, receiving treatment, counseling, preparation for discharge, etc. Therefore, the relationship between patient and number of tasks is captured in Figure 4.8. Realizing that patient is only an indirect unit of workflow contributes to modification on the following model elements: *Capacity Fulfillment Rate* and *Work Pressure.*

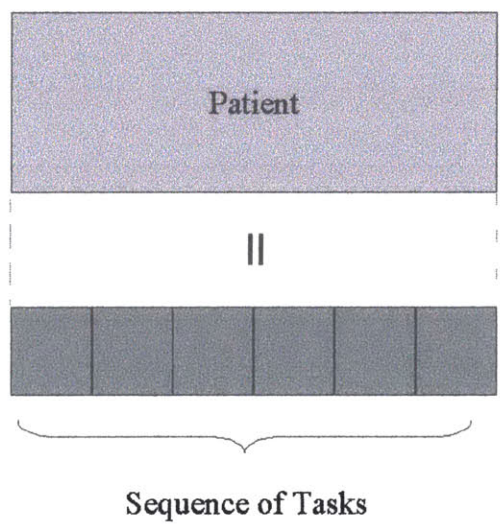


Figure 4.8 Patient represented by a sequence of Tasks

- Results from sensitivity tests indicate that there are more dynamics in the left hand side of the model (see fig. 4.6), which includes *Task to do* and *Task In Process Rate*, than right hand side, which includes *Task In Process* and *Task Done rate.*

- In terms of the effectiveness in controlling the task flow, the parameter "*Minimum Time to Admit*" has a larger influence than all other parameters.

- Building up additional capacity also has some impact. However, at this point, it is not certain how this strategy could apply to the real world since any financing implication related to capacity adjustment is outside the scope of this model.

All in all these insights indicate that in the real world the most efficient way to manage operational performance is to control the patient inflow, which is the number of people that visit the hospital. To control patient inflow requires controlling *Work Pressure*, and *Quality of Service*. This allows hospital to operate most efficiently for longer period of time. This strategy would be particularly effective when patient inflow is growing consistently.

4.6 Future Improvements to the Model

The following is a list of potential improvements that could be made to further our understanding of the behavior of the industry dynamics. These improvements can be added on without major changes in the structure of the original model.

- **Capacity structure could be refined**
  - Capacity structure can be improved by introducing other stocks such as stock of physicians, stock of nurses, and number of bed.

- **Financing**
  - Identifying and incorporating financing scheme will not only serve to better define a hospital revenue model but also identify any delay for capacity expansion.

- **Reputation**
  - Reputation can also be modeled in as a component for determining a hospital's competitiveness, which may in turn influence patient inflow.

- **More time factors**
  - Currently, not much dynamic behavior exists in the system. One of the reasons is due to the limited number of time factors in the model. Identifying additional time factors would help generate more dynamic behavior in the system.

- **More exact representation of Process Generating Rate**
  - Identifying *Process Generating Rate* in a more concrete and realistic term will add more reality to the system.

Chapter5 – Result, Insight and Discussion

In this chapter, the insights gained from the system dynamics simulation model are discussed in the context of how they correspond to the market focus for the prototype developed for our Master of Engineering project.

The most valuable insight derived from this modeling process is the importance of patient inflow control on the quality of care. Throughout interviews, many physicians are interested in using information technology to improve their workflow and thereby increase the efficiency for hospital operation. This means that physicians are focusing on increasing the discharge rate and shortening the time devoted to finish each task.

However, results from the simulation indicate this is actually an ineffective policy to maintain a consistently high level of quality of care. Simulation results indicate that workload for physicians will not be reduced until the number of potential patients is controlled. Simply providing a tool for physicians to work more efficiently will in fact have little effect on their workload. To lower the workload, which in turns improves quality of care, requires placing limit on visits by the potential patients. The concept of off-site home-monitoring system takes advantage of this insight by enabling patients to better take care of themselves, reduce the need for hospital visit, and thereby improves quality of care for all.

However, the idea of limiting patient inflow may seem controversial and contradictory to the traditional medical ethics which mandate "providing quality care to all those in need". Although this idealism and belief in social welfare is admirable and should be properly preserved, the benefits promised by the adoption of a home-monitoring system based on the principle of self-care are too great to ignore, especially in the face of unprecedented increase in the demand for health care services. The challenge, therefore, lies in the education of the public and physicians alike regarding the benefits of this novel concept. This is crucial because, as shown in the model, controlling patient inflow is the only effective policy to ensure our health care system can meet this enormous demand and still deliver high-quality care to all citizens on a consistent basis.

Reference

Aronson, Daniel, *Overview of Systems Thinking*, 1996
<http://www.thinking.net/Systems_Thinking/OverviewSTarticle.pdf>

Forrester, Jay W., *System Dynamics and the Lessons of 35 Years (D-4224-4)*, System Dynamics Group, Sloan School of Management, Massachusetts Institute of Technology, Cambridge, MA, 1991.
Also available at < http://sysdyn.mit.edu/sdep/papers/D-4224-4.pdf >

Forrester, Jay W., *Learning through System Dynamics as Preparation for the 21st Century (D-4434-1)*, System Dynamics Group, Sloan School of Management, Massachusetts Institute of Technology, Cambridge, MA 1994
Also available at < http://sysdyn.mit.edu/sdep/Roadmaps/RM8/D-4434-1.pdf>

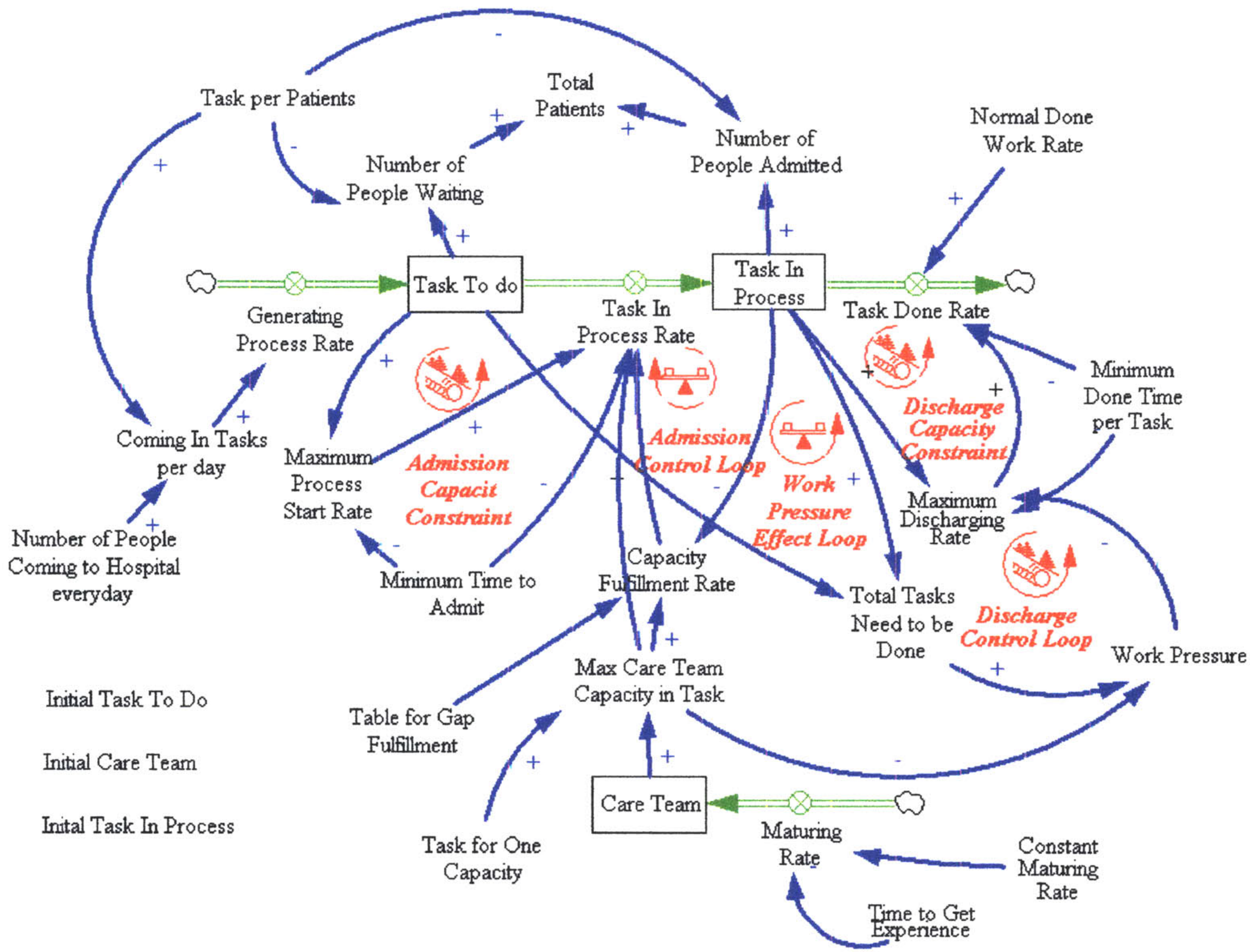
Forrester, Jay W., *Counterintuitive Behavior of Social Systems (D-4684-2))*, System Dynamics Group, Sloan School of Management, Massachusetts Institute of Technology, Cambridge, MA, 1995.
Also available at < http://sysdyn.mit.edu/sdep/Roadmaps/RM1/D-4468-2.pdf >

Kauffman, Draper L., *Systems 1: An Introduction to Systems Thinking*, McGruder Books, Appleton, WI 1980.

Sterman, John D., *Business Dynamics: System Thinking and Modeling for a Complex World*, Irwin MacGrow-Hill, Columbus, OH, 2000

Wolstenholme, Eric, *Patient Flow, Waiting and Managerial Learning – a systems thinking mapping approach*, Cognitus Management Consultants, 2002
< http://www.cognitus.co.uk/downloads/NHS_Patient_Waiting_Paper.doc >

Appendix1 – Simulation Model



(01) **Capacity Fulfillment Rate=**

Table for Gap Fulfillment

(Task In Process/Max Care Team Capacity in Task)

Units: Dmnl

"Capacity Fulfillment Rate" is the function of a *<u>table function</u>* *and the ratio of currently proceeding tasks and hospital capacity.*

(02) **Care Team= INTEG (Maturing Rate, Initial Care Team)**

Units: team

"Care Team" represents the number of the group of physicians who can perform medical procedure with average quality of work.

(03) **Coming In Tasks per day=**

Number of People Coming to Hospital everyday*Task per Patients

Units: Task/day

"Coming In Task Per day" is the number of tasks newly generated each day.

(04) **Constant Maturing Rate= 5**

Units: team

"Constant Maturing Rate" represents the number of the team that get sufficient experience to do a full one team assignment with average quality in any given time step.

(05) **FINAL TIME= 30**

Units: day

The final time for the simulation.

(06) **Generating Process Rate= Coming In Tasks per day**

Units: Task/day

"Generating Process Rate" is the value for generating tasks. This number increases as number of patients who come to hospital increases.

(07) **Initial Task In Process= 0**

Units: Task

This is the initial value for "Task In Process".

(08) **Initial Care Team= 23.5**

Units: team

This is the initial value for "Care Team ".

(09) **Initial Task To Do= 1000**

Units: Task

This is the initial value for "Task To do".

(10) **INITIAL TIME= 0**

Units: day

The initial time for the simulation.

(11) **Maturing Rate= Constant Maturing Rate/Time to Get Experience**

Units: team/day

"Maturing Rate" represents the number of teams that can acquire sufficient experience and become a team that has an average performance in a day.

(12) **Max Care Team Capacity in Task= Task for One Capacity*Care Team**

Units: Task

"Max Care Team Capacity in Task" represents current maximum capacity of the hospital measured by the number of tasks.

(13) **Maximum Discharging Rate=**

Task In Process/(Minimum Done Time per Task*Work Pressure)

Units: Task/day

"Maximum Discharging Rate" represents the number of tasks that they can finish in each day. This number varies when work pressure changes. When work pressure is higher each task takes longer to be done. Therefore, tasks per day will be decrease. In contrast, when pressure is smaller, number of tasks per day increase. This value never exceeds maximum number of tasks currently in process.

(14) **Maximum Process Start Rate= Task To do/Minimum Time to Admit**

Units: Task/day

"Maximum Process Start Rate" is the number of the tasks that we can start process at this moment.

(15) **Minimum Done Time per Task= 0.5**

Units: day

"Minimum Done Time per Task" represents minimum time for finishing a task under the normal circumstances.

(16) **Minimum Time to Admit= 0.25**

Units: day

"Minimum Time to Admit" represents the minimum time for starting processes for each task under normal circumstances.

(17) **Normal Done Work Rate= 3**

Units: tasks/day

"Normal Done Work Rate" represents the number of the tasks completed under the normal circumstances.

(18) **Number of People Admitted= Task In Process/Task per Patients**

Units: people

"Number of People Admitted" is the value converted from number of the tasks into number of patients.

(19) **Number of People Coming to Hospital everyday= 100**

Units: people/day

"Number of People Coming to Hospital everyday" is the average number of people who visit hospital.

(20) **Number of People Waiting= Task To do/Task per Patients**

Units: people

"Number of People Waiting" represents the number of patients who are waiting for receiving medical services.

(21) **SAVEPER= TIME STEP**

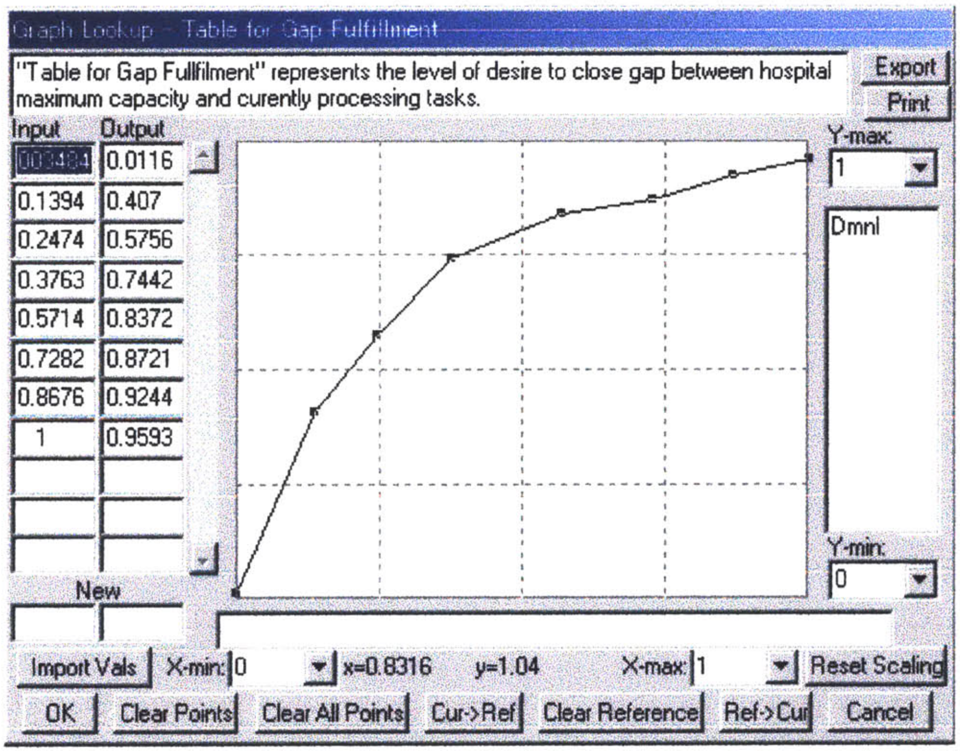
Units: day [0,?]

The frequency with which output is stored.

(22) Table for Gap Fulfillment

([(0,0)-(1,1)],(0.00348432,0.0116279),(0.139373,0.406977),(0.247387,0.575581),(0.376307,0.744186),(0.571429,0.837209),(0.728223,0.872093),(0.867596,0.924419),(1,0.959302))

Units: Dmnl



"Table for Gap Fulfillment" represents the level of desire to close the gap between hospital maximum capacity and currently processing tasks.

(23) **Task Done Rate=**

Min(Maximum Discharging Rate, Normal Done Work Rate/Minimum Done Time per Task)

Units: Task/day

"Task Done Rate" represents the number of tasks that are completed accurately. This number should no negative value for this variable.

(24) **Task for One Capacity= 5**

Units: Task/team

"Task for One Capacity" is the number of the task that's that one team can perform in average under normal circumstances.

(25) **Task In Process= INTEG (**

+Task In Process Rate-Task Done Rate, Initial Task In Process)

Units: Task

"Task In Process" represents the number of tasks that are currently under going and expected soon to be finished. Once new patients admitted this number increase.

(26) **Task In Process Rate=**

Min(Maximum Process Start Rate, Capacity Fulfillment Rate*Max Care Team Capacity in Task / Minimum Time to Admit)

Units: Task/day

"Task In Process Rate" is the rate of admission of people who have been queuing for receiving medical service.

(27) **Task per Patients= 5**

Units: Task/patients

"Task per Patients" is the number of tasks that one patients needs to go through from admission to discharge.

(28) **Task To do= INTEG (**

Generating Process Rate-Task In Process Rate, Initial Task To Do)

Units: Task

"Task To do" is the number of the tasks that are not yet started but certainly will be proceed since patients are already queuing for services.

(29) **TIME STEP= 0.015625**

Units: day [0,?]

The time step for the simulation.

(30) **Time to Get Experience= 180**

Units: day

"Time to Get Experience" represents the average time that one care team needs for gaining sufficient experience to become matured expert in the field.

(31) **Total Patients=**

Number of People Admitted + Number of People Waiting

Units: people

"Total Patients" is the sum of people who are currently admitted to the hospital for receiving treatments and those who are waiting for receiving treatment on the line.

(32) **Total Tasks Need to be Done=**

Task In Process + Task To do

Units: Task

"Total Tasks Need to be Done" is the sum of the number of the tasks that are currently in process and the tasks that are waiting for being proceeded.

(33) **Work Pressure=**

(Total Tasks Need to be Done)/Max Care Team Capacity in Task

Units: Dmnl

"Work Pressure" is ratio of number of all tasks needed to be done and how much tasks that hospital can carry.

Appendix2 – Interview Log

Meeting log:

Beth Israel Deaconess Medical Center

Mr. Sands, MD

Director of EPR and Communications

Division of Clinical Computing

Division of General Medicine and Primary Care

Apr 8 2002 3:30-4:30PM

Process of the introduction of new technology is not a rational decision.
Different set of motivation for each hospital & physicians:
Resource constraint environment and optimization of the operation
IT as benefit generator
Benefit for the patients (?)

Issues of introduction of the system for hospital:
Investment issue
User issue
For doctors, IT is utility
For finance dept., IT is core technology
Learning curve issue
System integration issue with other system is the hospital
it is hard to introduce a new system for one small team in the large hospital
Economy of Size works when new system is introduced. (Many physicians support the new system. But top down rarely works.)

*Practicality of the wireless is very attractive, but UI is not good enough. Devise constraints the ability to input data. (hard to get data into the system)

What kind of features would attract physicians to use new technology?

Motivation:

Quality of care

Prove process

Safety of patients

Capital:

External pressure:

Publicity

Media

Pressure from HMO

Actual implementation = Motivation + Capital + External Pressure

Willingness of adopting new technology define the success.

Willingness:

Go home earlier

Increase income

See more patients

Charging System:

Capitation:

Given max covered payment on each patient regardless how many you see the patient:

i.e.) 100 dollars per patient per month.

reduce number of visit. You already know how much you can get in max. Then what you can do to generate revenue is cut cost.

Non-capitation::

Fee for service policy.

Revenue = $ per given service in each visit.

This become more general trend across the nation. California is an exception

Ref: cms.gov and National Marge Healthcare Congress

When we look at the data here, we need to care how to read the data.

#% of all patients over all. Not in particular age group because demographics are significantly different.

Receiving more patients contributing more revenue. Thus efficient operation is critical.

Fear for over loading. Carry too many patients to do a quality work.

Why many physicians did not purchase integrated health care system while Caregroup already introduced the same kind of system.

Lack of Capital

Lack of will (Upper management level and Physician level)

Political factors

It is easy for upper management to say that each of divisions will by whichever system that fits their work.

Physicians are very powerful in hospital

Each physician is very influential. Management does not want create any confliction with them to run the hospital efficiently.

In individual system wise, many physicians will refuse to use although hospital decided to introduce new system.

For the physicians, IT System is utility. Not the core skills that brings them money. Whether digital or paper they charge the same money.

Introduction of the new system usually creates additional costs.

Adoption cost (Learning curve: usually 6 month)

Work habits (Physicians are accustom with using papers since they have done last 10-15 years)

Maintenance (Mede Care requires high performance of the system at initial level, introduction point)

Ultimately, physicians care the most about themselves. They do not welcome IS when they know introduction of such reduce their work performance even if it is temporally.

Why still some of the system can be sold?
Bad product, good sales representative.

When Introduction of the new technology is welcomed and actually used
The case when physicians themselves demand the clinical computers

The case physicians feel OK to adopt the New system
Time neutral (there would be no different in time of the work process)
No different in revenue
Improve quality
Satisfaction of the work

Doctor's work s and tasks might be improved by introducing IIS(Integrated Information System)
Prescription
Result Look up
Communication among team
Billing
*Communication with patients may create additional work with is not always beneficial

In many case physicians already have sufficient data on patients. Overloading of the data is the real issue. If they have more data they cannot ignore them. Our system provides too much data to handle.

Financing is the major motivation for physician. (Financing as money that they can recive.

Not money for research and so on.)

Clinical physicians' finance?? => Salary (Practice is not good business because investment is so large.)

Competition factor:
Hospital level competition
Practice level
Physician level

*One doctor provides better service due to IT then, other physicians will adopt Its.
Insurance company constrains the choice of hospitals but still patients can choose doctors.

Payment delay by insurance company.
No interest for late payment
IT increases value of the time for doctors.(More delay payment, more money insurance company owes doctor a money)
Accumulation of un-paid service will create the fear and uncertainty of pay back for their service and investment. This boost negative attitude toward to invest their environment. See panic model, oil shock model.

TRICIA BOURIE, NURSE

Tbourie@caregroup.harvardhealth.edu
Meeting from Wed of 4/10/2002 10:00AM
9:45AM at Starbucks @ Harvard medical

Meeting log:

Harvard Medical

Tricia Bourie

20 years experienced in-patient nurse, interventions cardiology

Apr 10 2002 10:00-1:00PM

Nurse types

In patient

Patient who has a serious symptom and needs to be admitted to the hospital. In another word, patient who needs a bed

Out patient

Patient who does not need a bed.

Nurse practitioner

Nurse who can do some work that what doctor does. In a way, they are more similar to doctors. They are contributed to reduce Doctor's workload.

Licensed nurse

Preparation for the doctors diagnosis such as taking temperature, blood pressure level and so on.

Doctors are mainly focus on making a diagnosis.

In patient nurse are more likely to work like " following the order" way.

Main tasks for in-patient nurses:

Daily routine

Check & monitoring patient's condition and update the record
Prescribe the medication and treatment that doctor ordered.
Take a note about the progress
Summarize the note and fill out those results on patient record form, which is in nursing station.

If condition seemed stable and better nurses can discharge them.
Practitioners nurse can change the amount of medications and so on.

Manage medication
Handling doctors order
Go to pharmacy
Check whether that medicines fit to patient medical history
Make sure that patient takes the medication
Check the side effect

Planning the discharge process.
Followings are some of those discharge processes:
Teach maintenance (exercise so on)
Health service related information
Next phase of treatment
Impact of the disease
Difference the health before and after
How to get help

Average number of patients
Morning Shift: 5 people
Evening Shift: 5 people
Night Shift (11:00PM-7:00AM): 9-10 people

*sometimes like 2 discharged, 2 new admitted total four

Most used form by nurse
Physician order form
Process note (white note paper with lines)
Nurse form (nursing order form)

Filled forms were mainly filed, majority of them, in a binder and stayed in nursing station.

Storage of the information:
Binder, summary of the note take by individual nurse, at the nursing station
Some of the information is kept the bedside.
Some others are on the flow chart
Some others are on the card and small note pad used for nurse taking note.

Experienced nurse does not write whole thing what she observed. She summarizes what she thinks important. Inexperienced nurses write every thing see observed.
What a nurse need to file a record are quite different in the field of professions. Therefore, Tricia who has 20 experiences in interventions cardiology has to learn from ZROM if she starts to work in the other field tomorrow.

However, whether not well summarize in the file does not defines the quality of the work for nurse.

Inside of the binder is not necessary to be the exactly the same what you write on your notepad, flow chart, and bedside note. Most likely summary of them

Handful device for nurse was already for introduced. One the one hand it is very convenient for looking out put input. On the other hand input method was not convenient enough. So, devices are not fully used.

The current integrated information system used by care group is multiple application system. Execute multiple applications that allow nurses and doctors to access each different database physically located different places. There are no compatibility in transferring data. In a sense, it is very similar to lay down all different chart on the floor and use them.

This multiple application system is convenient in the following case:
There are patients' digital records and some fields are missing. Nurses know that some other database has those missing data in other database. However, they do not look up other database. Instead, they ask patients because that is much faster. As a result, patients were asked exactly the same question every time they visit hospital.
=> nurses are time sensitive. It is easy way to go with old way

New doctors -> do not know how the hospital system works.
They are intelligent but nurses know more than a new doctor knows because of experience. In fact, the highest mortality in any hospital is usually July and August because of new doctors.
Nurses are like a knowledge pot. They usually help new doctors to learn.

A nurse talks to doctor one on one regarding patients and gives them not only data but also their opinion. This communication will be helpful for new doctors both in learning practical medical skill & knowledge and understand each other, facilitating good relationship.

Current system is integrated but can be improved better. (Database is still scattered)
Past medical history
Surgical history
Are fairly available under current system

Particularly in the teaching hospital, new doctors are allowed to make minor mistakes and lean through them. In the community hospital, environment is not that generous.

ER: quick decision-making is crucial. Following protocol style work environment. (Protocol based process and execution)
They are more willing to use data for their work because of this nature. (Using data statistics help new doctors to learn quickly)

Useful usage of computer for nurse:
Discharge plan

ORDER PLAN

Look up result

Requirement for hospital system requirement: Zero down time

Currently, nurses keep paper (note and forms) as back up.

Charting time => private time for nurse(do not want with patients)

Benefit of On-Line=> getting information that is not fit any column in the cart provided by family member.

Appendix3 – E-health Project Proposal Presentation

M.Eng. Project Proposal

Knowledge Based E-Health

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Personnel

Project Supervisor
Profs. John R. Williams

Technology Manager
Tashan Yen

Project Manager
Sakda Chaiworawitkul

Developer
Andrew Ferriere

Marketing Manager
Glorimar Ripoll

Developer
Pai-Fang Hsiao

Marketing Manager
Osamu Uehara

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Agenda

- Part 1: Overview of Industry *by Tashan Yen*
- Part 2: Opportunity *by Tashan Yen*
- Part 3: Schema of Solution *by Osamu Uehara*
- Part 4: Open Issues *by Sakda Chaiworawitkul*
- Summary

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Part 1
Overview of Health Care Industry

by Tashan Yen

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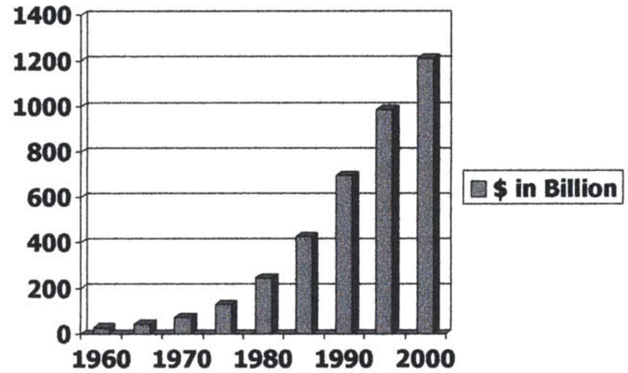
Market Size

- Size of U.S. Health Care Industry = 1.2 trillion
- Size of European Health Care Industry = 700 billion



U.S. Health Care Industry: 1960 ~ 2000

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Players

- Health Insurers
- Managed Care Organization (MCO)
- Employer
- State/ Federal Government

- Hospitals/Networks
- Surgicenters
- Nursing Homes
- Physician Management Companies

- Pharmaceuticals
- Medical Devices
- Pharmacy
- Info. System

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Issues

•Management of escalating cost

•Patient discontent due to perceived decline in quality of care

Trend

•Rising patient "consumerism"

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Issues

•Management of escalating cost

•Patient discontent due to perceived decline in quality of care

Trend

•Rising patient "consumerism"

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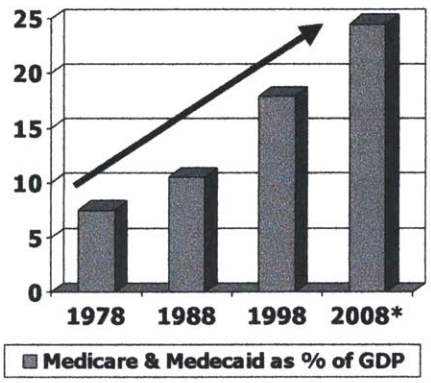
Payer: Increasing Government Expenditure – Medical Service



- U.S. federal government spent 17.9% of budget ($319 billion) on Medicare and Medicaid in 1998.
- By 2008, projected to be 24.5% ($620 billion)

Source: Bureau of Labor Statistics, Monthly Labor Review, Nov. 1999.

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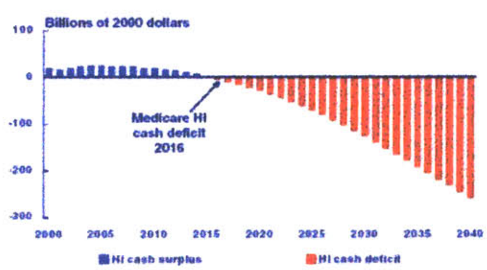
GAO Forecast

- "By 2030, Social Security, Medicare, and Medicaid will consume more than three-quarters of total federal revenue -- without outpatient prescription drug coverage." - David Walker, Comptroller General of the United States
- Medicare deficit coming due to retiring Baby Boomers

Figure 2: Medicare's Hospital Insurance Trust Fund Faces Cash Deficits as Baby Boomers Retire



Source: GAO-01-1010T

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Private Sector – Cost Trend Survey

- Double digit increases across the board

Product	Annual Trend Rate 2002 (cost/price increase)	Annual Trend Rate 2001 (cost/price increase)
Health Management Organizations (HMO)	→ 11.7%	9.3%
Point of Service Plans (POS)	12.3%	10.9%
Preferred Provider Plans (PPO)	13.7%	11.5%
Indemnity	15.5%	13.8%
Prescription Drugs (Rx)	→ 22.1%	19.6%
Indemnity Dental	9.2%	7.1%
PPO Dental	8.2%	7.2%

Source: Arthur Andersen

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With the increasing in size of medical care market, every player experiences cost pressure

Cost reduction is the most straightforward policy

BUT!!

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Issues

•Management of escalating cost

•Patient discontent due to perceived decline in quality of care

Trend

•Rising patient "consumerism"

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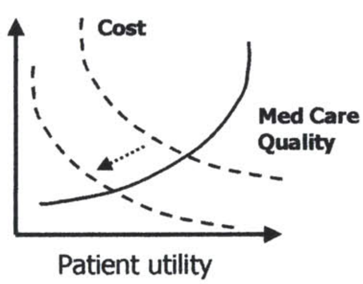
Dilemma: Quality of Care vs. Cost



Reduction of cost without regard to quality of medical care = patient dissatisfaction

Problem:

Balancing act – maximizing efficient use of medical resources while providing optimal quality of care to patients

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Issues

•Management of escalating cost

•Patient discontent due to perceived decline in quality of care

Trend

•<u>Rising patient "consumerism"</u>

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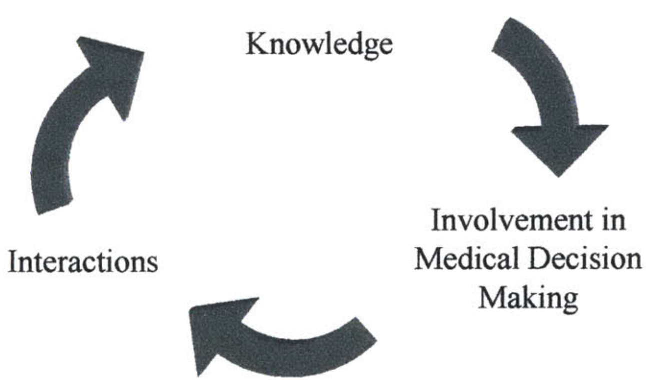
Rising Patient's Consumerism



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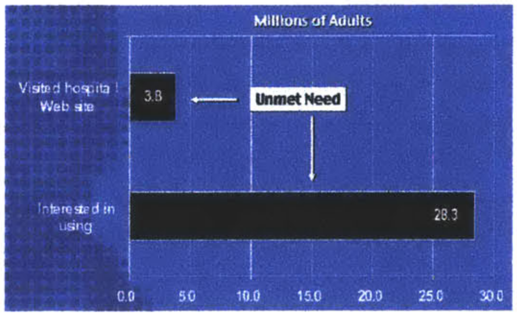
Rising Patient's Consumerism: To Know More



- Patients know more than ever before
- Patients want to be more involved in decision-making

Source: Cyber Dialog

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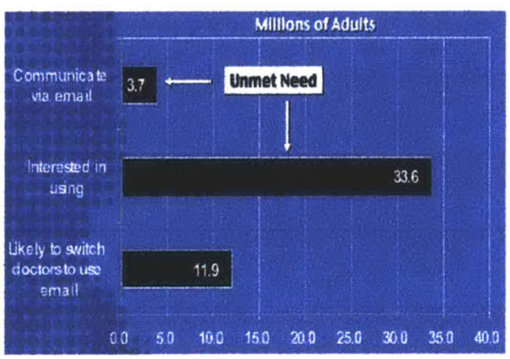
Rising Patient's Consumerism: Desire for Interaction



- Demand for interactions is high
- Not enough supply

E-health strategy should enhance communication between both sides

Source: Cyber Dialog

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Part 2
Opportunity

by Tashan Yen

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Objective (Opportunity)

✓ Management of escalating cost
✓ Patient discontent due to perceived decline in quality of care
✓ Rising patient "consumerism"

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Proposed Solution Outline

- Evidence based: emphasizing ongoing health maintenance with feedback from health professionals
- Systematic approach: focusing on outcome, not just individual procedure.
- Best practice: analyzing the utilization of resources in given situation over a number of episodes

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Part 3

Schema of Solution

by Osamu Uehara

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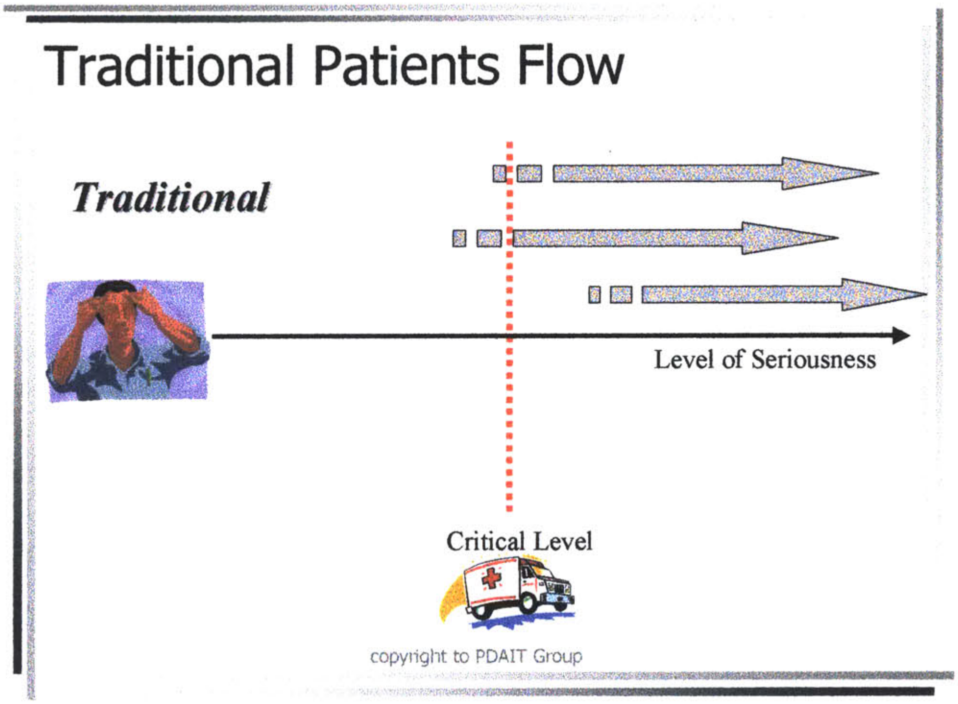
Traditional Patients Flow
Traditional
Level of Seriousness
Critical Level
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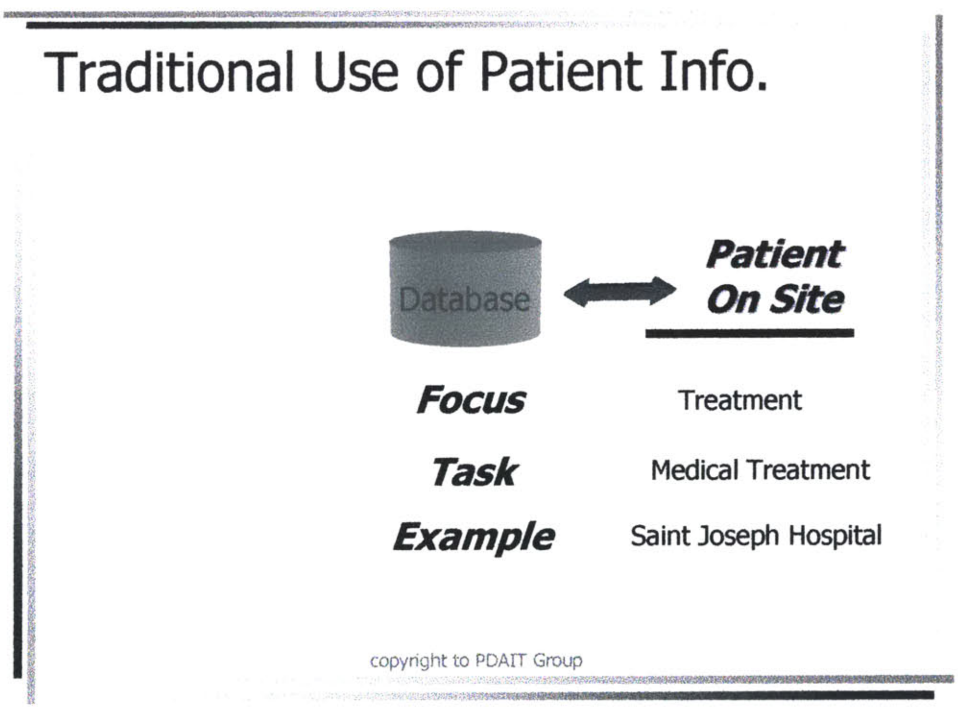
Traditional Use of Patient Info.
Database
Patient On Site
Focus
Treatment
Task
Medical Treatment
Example
Saint Joseph Hospital
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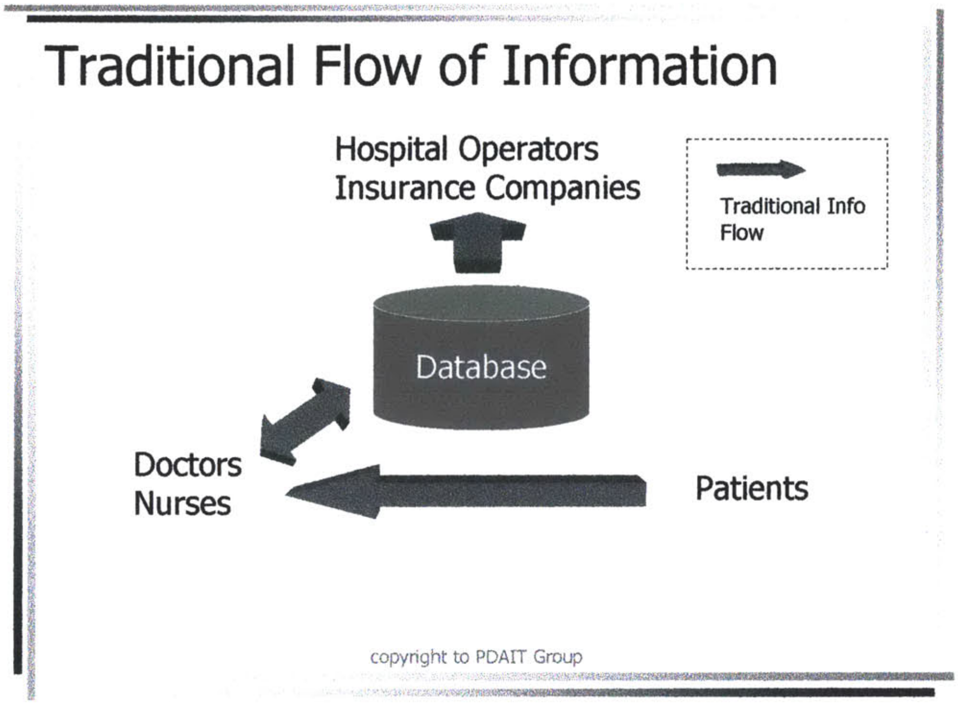
Traditional Flow of Information
Hospital Operators
Insurance Companies
Traditional Info Flow
Database
Doctors
Nurses
Patients
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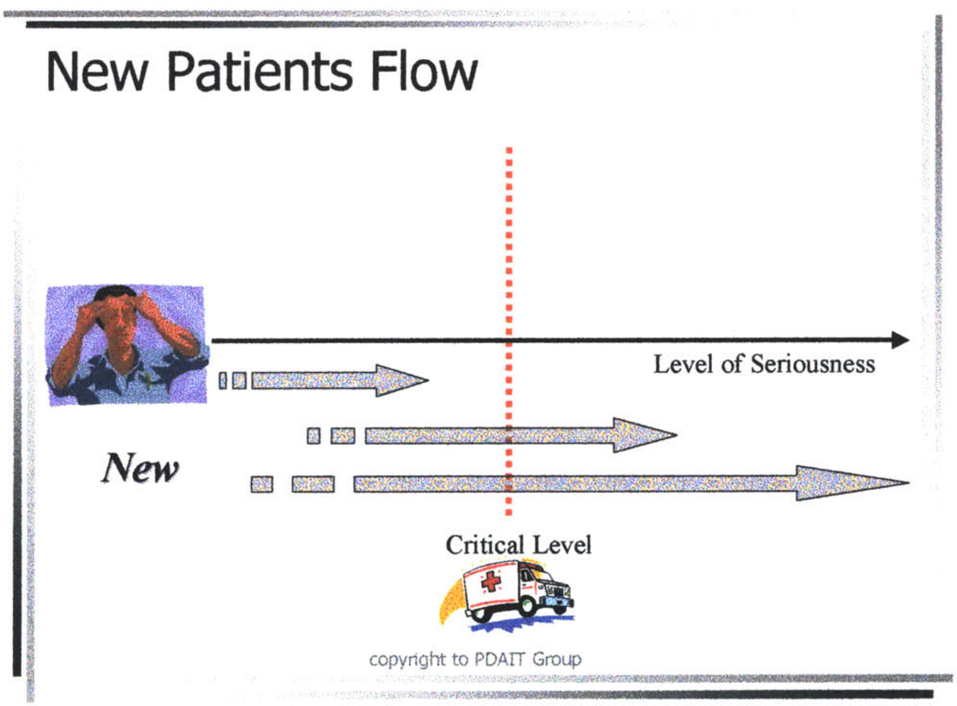
New Patients Flow
Level of Seriousness
New
Critical Level
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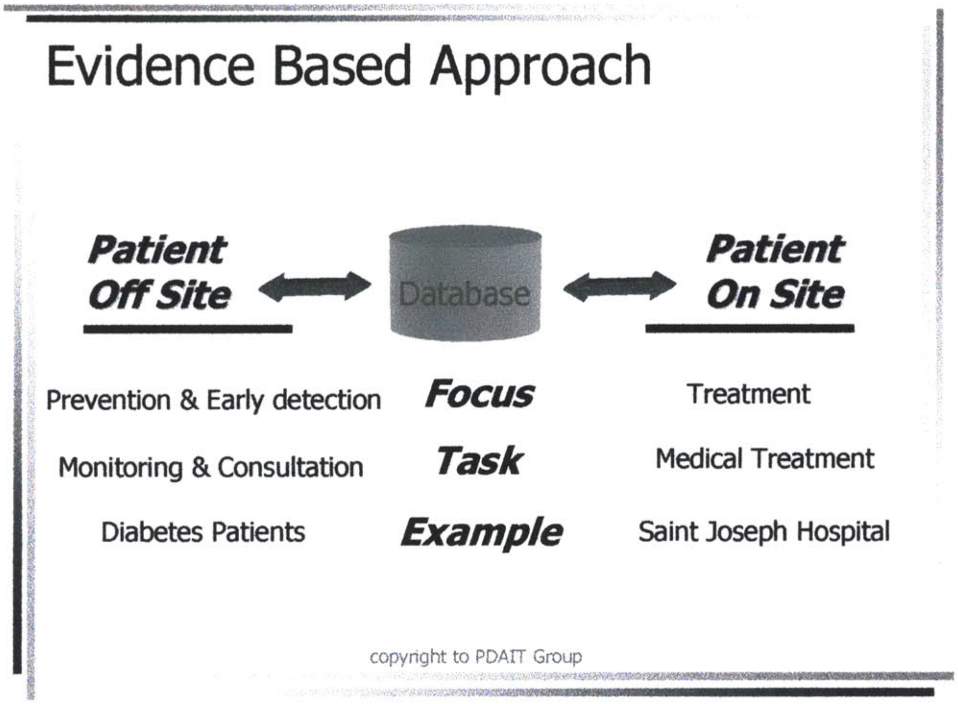
Evidence Based Approach
Patient Off Site
Database
Patient On Site
Prevention & Early detection
Focus
Treatment
Monitoring & Consultation
Task
Medical Treatment
Diabetes Patients
Example
Saint Joseph Hospital
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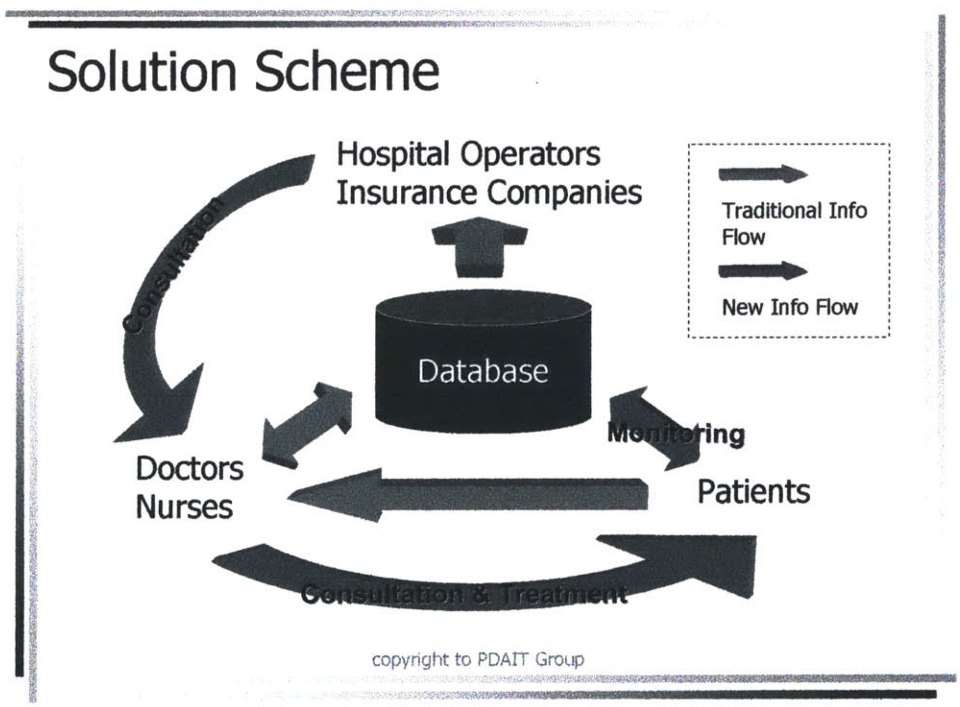
Solution Scheme
Hospital Operators
Insurance Companies
Traditional Info Flow
New Info Flow
Consultation
Database
Monitoring
Doctors
Nurses
Patients
Consultation & Treatment
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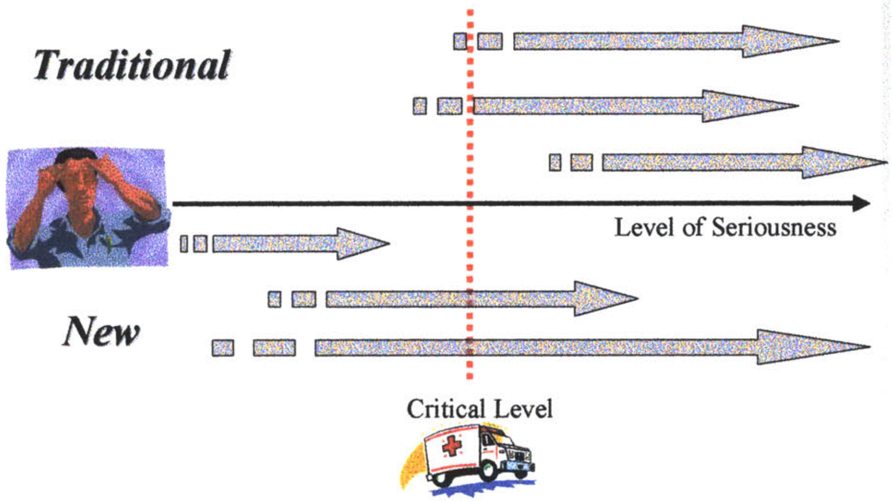
Traditional vs New - Patients Flow



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On Site Example: Saint Joseph Hospital

- Introduced Wireless LAN to 600 bed hospital in Denver
- Nurses carry a Laptop PC with Wireless LAN and access, or update, patients data
- Currently, installed 70 Wireless Notebook PC

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Off Site Example: Cases in the U.S.

- Wireless vital monitor equipment achieved a 95% reduction in hospitalization rate. (Heart Alert near Atlanta)
- An 18-month study revealed that the wired subjects reduced their emergency room visits by 88 percent while slashing their hospital admissions 92 percent. (Mass. Memorial Medical Center)

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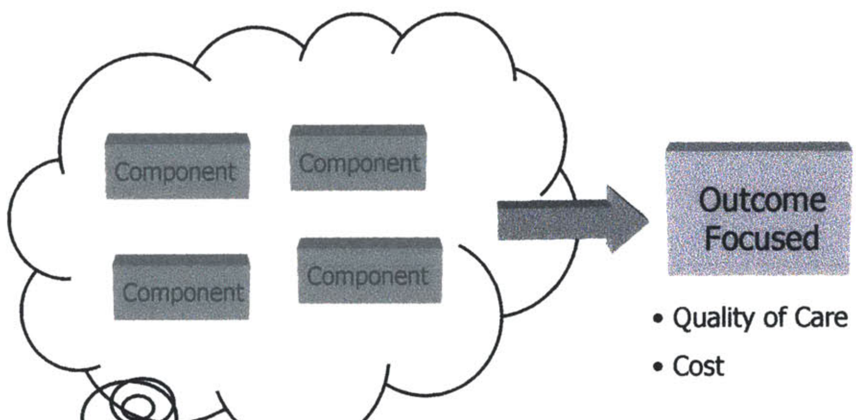
Systematic Approach



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Benefits

- Patients:
  - Benefit from constant attention from doctors.
  - Cost reduction (Time & money)
- Doctors:
  - Reduction in their workload, which allows them to maintain their quality of work.
  - More patients information through the web.
- Hospital operators:
  - The best practice will help them to control their quality of service easier.
  - Consultation to the doctors based on service quality vs cost analysis.

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Part 4
Open Issues

by Sakda Chaiworawitkul

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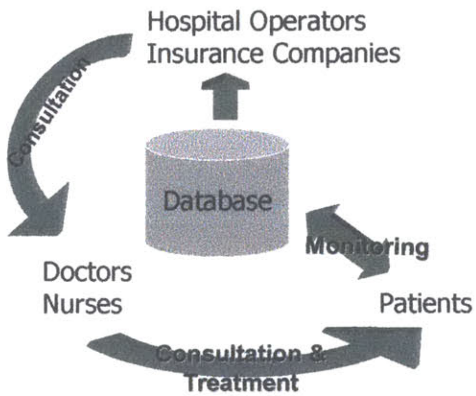
Solution Scheme (Revisited)



Open Issues:

1) Clinical interactions
2) Relationships between physicians and patients
3) Difficulty in Adoption
4) Database ownership/ Info. Security

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Clinical Interactions: Overview

- For E-cared management to be achieve, interaction between physicians and patients is important
- Emerging internet-based tools and services presents new opportunity to enhance this kind of interaction
- How??

Next generation of patients and doctors relationship?

Source: Cyber Dialog

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Relationships Between Doctors and Patients: Overview

- Traditional relationship is asymmetric. Mostly, only doctors who give clinical advice or knowledge
- With the emerging internet based technology, e-health service becomes promising in the market
- Patients become more knowledgeable and more involved
- <u>It makes the relationship symmetric and more interactive</u>
- Doctors are starting to change the way they work with them

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Difficulty in Adoption by Doctors

- So far, the demand for interaction has been driven by patient side
- Physicians, at the moment, are *not* looking to e-health to provide a new and better way to practice medicine
- They are mainly interested in tools that save them time and money

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Difficulty in Adoption by Health Care Providers

- Many companies think of adoption of e-health as replacement of paper-based and human works by electronic form → Reluctant to implement
- Because there is relatively small new economic value for them to create
- But clinical e-health offerings will allow the companies to increase their influence over how doctors practice medicine
- <u>However, the hurdles to persuading doctors to adopt them are high!!</u>

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So……

To persuade physicians to adopt e-clinical health tools mean the companies must address

- Safety – privacy and security
- Efficacy – data on how tools are improved efficiency

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Database Ownership/Security

Who owns the database will be an important issue to decide the business model

- Centralization Idea: Center organization owns the database – security, regulation of data use?
- Localization Idea: Every hospital or individual owns the database directly – accessibility and compatibility between different data system?
- Third Party: Insurance company for example – inappropriate of data use

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Summary

Problems	Solutions
Cost	Evidence Based
Quality of Care	Systematic Approach
Consumerism	Best Practice

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Market Size

- Size of U.S. Health Care Industry = 1.2 trillion
- Size of European Health Care Industry = 700 billion
- Looking from market capitalization it is even larger
  - 2,346 billion in U.S.

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Players

- Products/Supplier
  - Pharmaceuticals – Pfizer, Amgen
  - Medical Devices/Suppliers – Meditronic, Baxter
  - Pharmacy – CVS, Walgreen
  - Information System
- Provider
  - Hospitals/Networks – HCA, Tenet
  - Surgicenters
  - Nursing Homes
  - Physician Management Companies
- Payers
  - Health Insurers – Aetna
  - Managed Care Organizations (MCO) – HMO, PPO
  - Employers
  - State/Federal Governments

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Dilemma: Quality of Care vs. Cost

- Balancing act – maximizing efficient use of medical resources while providing acceptable quality of care to patients

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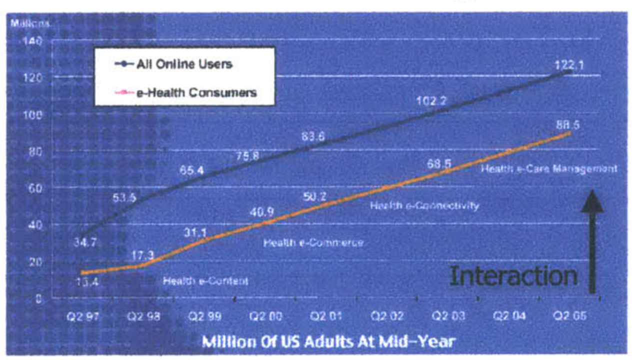
Clinical Interactions:

- It also increases individual's concern towards health
- Health e-Content ⟶ e-Care Management



This increasing interaction will effect relationship between doctors and patients??

Source: Cyber Dialog

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Relationships Between Doctors and Patients : Patients

- Patients are segmented into 4 categories on the basis of their severity of their medical condition, i.e. *accepting, informed, involved and in control*
- The last two groups take most active role and deploy internet as their essential not optional- channel of information
- Speed of migration from inactive to active role of patients is substantial

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Existing Approach

Approach	Characteristics	Problems
Event Based	Emphasizing medical treatment over prevention	By the time patient checks in hospital the medical resources required are often enormous
Component Based	Emphasizing procedure over outcome	Resources wasted on optimizing individual processes, not focusing on outcome

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End

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