

# An Investigation of Hospital's Sustainable Supply Chain through System Dynamics Model

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Received: 11 September 2021

Accepted: 03 October 2021

Published: 06 December 2021

## Abstract

The supply chain in healthcare is unique and different from other supply chains in many respects. Today, the concept of a new sustainable supply chain has been widely discussed. Hospitals and treatment centers have the highest energy consumption compared to other service providers; Hospitals are considered as sources of waste production in cities. Cost plays a vital role in their performance and healthcare due to providing services to patients, and the number of its high staffs has a high societal impact on the community than other services and the satisfaction of the stakeholders, especially the patients, including the challenges is. Therefore, achieving sustainability in the supply chain of health care is essential and essential. The sustainable social dimension is one of the crucial areas in the supply chain of health and treatment. As the patient satisfaction index is an essential factor in the social dimension of supply chain health, the employee satisfaction index is also necessary. In addition to the social dimension, the economic dimension is also partly explained in the causal chart, which is indicated by the B/C indicator that shows the benefit-cost ratio in the hospital. In this paper, the variables related to the sustainability and social-economic dimension of their relationships in the supply chain of the hospital are examined using the system dynamics approach.

**Keywords:** Hospital Supply Chain, Sustainability, Patient Satisfaction, Staff Satisfaction, System Dynamics.

## How to cite the article:

M. Abdolmohammadi, A. Riahi, An Investigation of Hospital's Sustainable Supply Chain through System Dynamics Model, Medbiotech J. 2021; 5(4): 18-24. DOI: 10.22034/MBT.2021.140297

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## 1. Introduction

The healthcare supply chain has a complexity compared to other industries and, despite its importance, has received less attention in studies. Flows in the healthcare supply chain include physical products, financial flows, and information. The primary goal of health care organizations is to improve community health, patient, and staff satisfaction in the workplace. Sustainability in the supply chain means pushing the supply chain towards the social, economic and environmental aspects of the supply chain and resolving problems

in these dimensions in the traditional supply chain (1). Organizations need to change their supply chain based on environmental protection and improve their social and economic performance with new management practices. Little research has focused on the sustainable healthcare supply chain based on three economic, social, and environmental dimensions. The three dimensions of sustainability are interrelated and reinforce each other (2). As an essential part of the health care system, as well as delivering quality health care, health centers as an essential part of their supply chain can reduce their environmental

impacts and also earn economic and social benefits. Health care organizations have an excellent opportunity to influence sustainable performance because of their high energy consumption, significant waste generation, and high social impact on society and the provision of services to patients and their health and the community (3). System dynamics is a system modeling tool for understanding the behavior of complex systems such as health care. The dynamics of the system help to better understand the health system and the factors and relationships between them. This method can also be used to understand system stability. System dynamics can help people understand the impact of change and make better decisions about health care systems and sustainability challenges. Kuchan et al. found that weak demand and inventory outlook leads to a mismatch between demand and supply of health products that can have adverse economic and patient care consequences (4). They used cloud computing, an enabler of electronic supply chain management systems, and auxiliary information sharing in the hospital supply chain with a system dynamics approach. Hospital Supply Chain This article covers hospital pharmacy levels, drug distributors, and manufacturers. The findings show that cloud-based information sharing enhances visibility in the health supply chain, and with this increase, hospital responsiveness to demand improves. Faizi Pour and Ferreira have examined the social dimension of health sustainability. Patient satisfaction is a key factor in the social element, and patient satisfaction reflects patient expectations about cost, access to services and resources, and patient health. Important variables and their relationships in social health sustainability related to patient satisfaction were investigated using a system dynamics approach (5). Mutiny and Mawbawa, presented a systematic thinking approach for analyzing individual and overall satisfaction with related variables and their relationships in the health care system. Just as patient satisfaction, which is recognized as an essential factor in the social sector of health care sustainability, is also essential for staff satisfaction (job satisfaction) and organizational effectiveness (satisfaction) (6). They proposed a set of satisfaction indicators defined in terms of satisfaction perceived by the three 'patient, employee, employer' players in the healthcare system. Al-Jabri et al. identified sustainability variables, introduced a hierarchical framework for measuring and prioritizing sustainability variables in the healthcare industry. These variables include Lean Management, Patient Satisfaction, Staff Satisfaction, Continuous Improvement, Corporate Social Responsibility, Brand, and Accreditation (7).

Bergerdi et al. for 6 months, evaluated patient satisfaction and experience of paramedical services in a health care center in India and measured patient satisfaction with medication, nursing care, integrated health services, and hospital infrastructure reviewed and sought to improve these areas to increase overall patient satisfaction. Social sustainability in the service sector in general and in the health care sector, in particular, is relatively new (8).

Matloub Hossein et al. in their study, examined social sustainability in the service sector and identified the motivations, barriers, and factors for social stability in a health care supply chain focusing on four stakeholders: suppliers, staff, patients (Identified by the government (and owners)). Inputs, such as staff provided and used by key health care processes, are outputs, products, and services, processes and customers, community, and patient. The results of the study showed that while focusing on each stakeholder is important, a comprehensive analysis of all stakeholders' perceptions of what constitutes a sustainable social supply chain will bring more benefits and help hospital managers balance the expectations of all parties involved (9-12).

Shafiee Nikabadi et al. highlight the importance of patients' role as health care clients in determining the quality of service and considering the health care supply chain that aims to create maximum value for clients and is critical to the survival of health care organizations. They have presented a dynamic model for the health care supply chain focused on the emergency department and incorporating patient treatment steps in the ward using system dynamics approach and behavior analysis with regard to the whip effect at Babol Rouhani Hospital (13-16).

Salimi Taklo, in his dissertation, aims to configure the hospital's sustainable supply chain at the three levels of supplier, hospital and patient and simultaneously consider all three sustainability dimensions using only the perspective of hospital experts, from the dynamics approach. The system has been used to simulate and run the model in Kerman hospitals. As patient satisfaction is a key focus of the healthcare supply chain, the expectations and expectations of health care workers are expected to reach a minimum acceptable level to create a sustainable environment. Paying attention to hospital staff satisfaction has social sustainability. The goal of the hospital is to have a healthy population. The sustainability of financial resources leads to uninterrupted and uninterrupted service to patients (17-20). Therefore, it is necessary to examine the sustainability of the hospital supply chain. Investigating the variables related to patient and staff satisfaction and their relationship to the

social dimension of the hospital supply chain helps. This article attempts to extract the literature that contributes to the sustainability of the hospital supply chain by reviewing the literature and drawing on the cause and effect model using the system dynamics approach. The purpose of the proposed model is to investigate the effect of factors in the hospital system on the social and economic dimensions of sustainability in this system. Social dimensions include staff and patient satisfaction indicators; the economic dimension is examined with the B / C index (21-24).

## 2. Research Methodology

### 2.1 System dynamics model

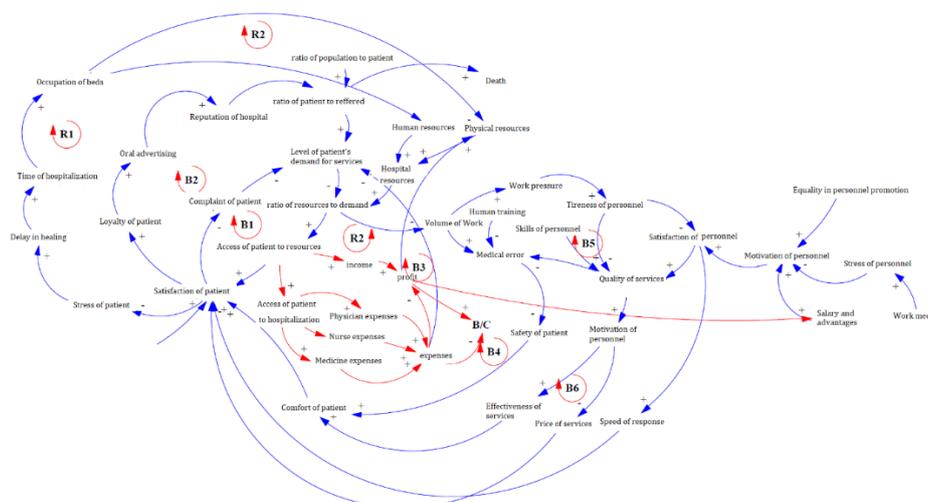
This study aimed to identify the main variables and their impact on patient and staff satisfaction for social sustainability in the hospital supply chain. The cause-and-effect model is shown in Figure (1). The set of variables and their relationships are related to patient and staff satisfaction, and B / C in

the cause-and-effect diagram, the relationships between variables are represented by an arrow, each arrow having a positive or negative sign indicating the nature of the relationship between the variables in the model (7, 8, 17, 25, 26). The symbols in the loops indicate the type of behavior that the system suggests. Positive loops (R) are growth loops in which the change in one direction grows in the same direction, and negative loops (B) are the target loops in which the loops try to fit the system to the desired state. Patient and staff satisfaction is influenced by social, economic, and environmental dimensions.

Table (1) shows a list of variables related to patient and staff satisfaction indices and B / C indices for health supply chain sustainability in this study. The B / C index shows the hospital-to-cost ratio as a symbol of the economic dimension in the cause-and-effect chart (27).

**Table 1:** Hospital supply chain sustainability indicators

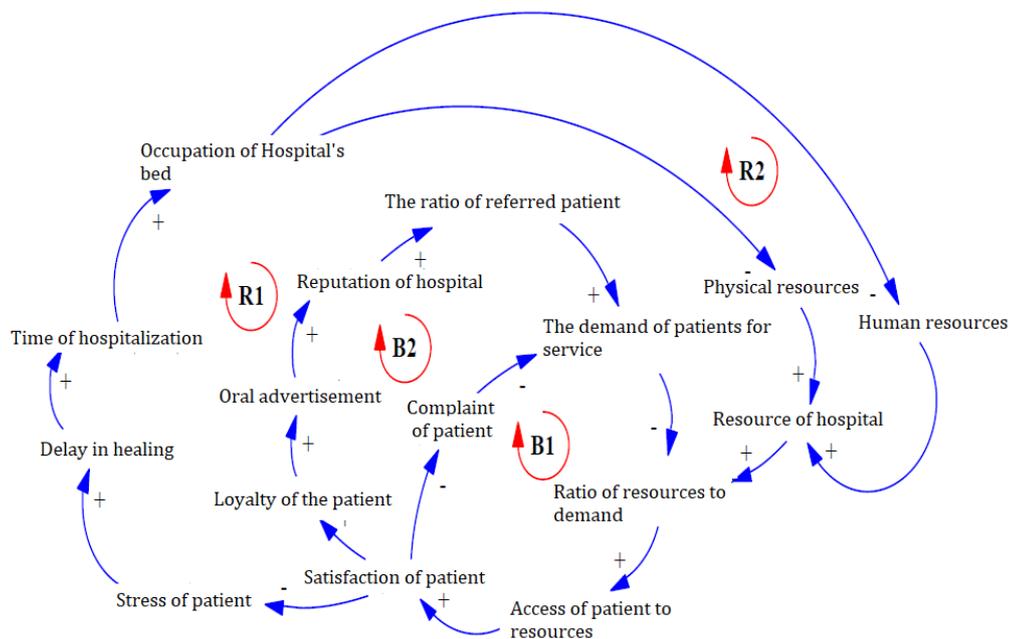
	Index	Variation
<b>Social impact</b>	Personnel satisfaction	<ul style="list-style-type: none"> <li>• Comfort of patient</li> <li>• Complaint of patient</li> <li>• Loyalty of patient</li> <li>• Access of patient to resources</li> <li>• Cost of services</li> <li>• Speed of responsiveness</li> <li>• Stress of patient</li> </ul>
	Patient Satisfaction	<ul style="list-style-type: none"> <li>• Tiredness of personnel</li> <li>• Quality of service</li> <li>• Mental condition of personnel</li> <li>• Skills of personnel</li> <li>• Medical error</li> <li>• Job motivation</li> </ul>
<b>Financial impact</b>	B/C	<ul style="list-style-type: none"> <li>• Profit</li> <li>• Cost</li> </ul>



**Figure 1.** Diagram of cause and effect in hospital and the relation of patient, hospital and personnel.

Patient Satisfaction Loops: In figure 2, B1 loop decreases with increasing level of patient demand for health services, reduced resource availability, and patient access to resources. As patient access to resources declines, patient satisfaction decreases, and patient complaints levels increase, resulting in decreased patient demand for services. In the R1 loop, with increasing physical resources, hospital resources increase resources to patient

demand ratio increases, leading to improved patient access to resources. This leads to increased patient satisfaction and reduced patient stress and anxiety, which reduces the delay in recovery, thereby reducing the length of hospital stay and lower bed occupancy, leading to more access to physical resources in the hospital (7, 27-29).

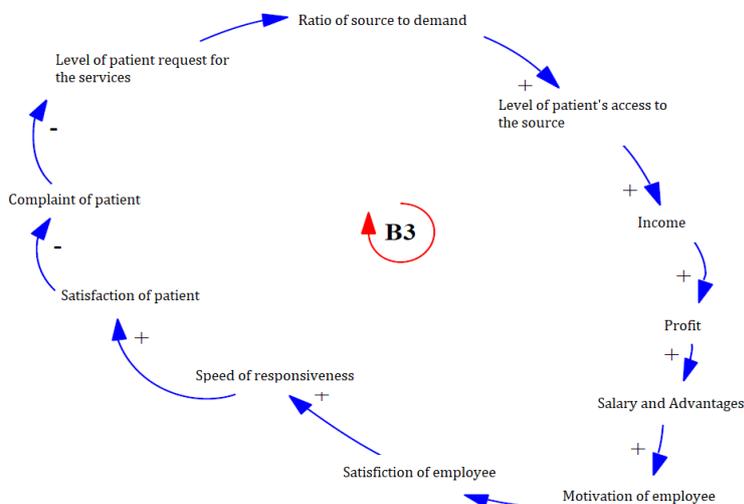


**Figure 2.** Patient satisfaction rings in hospital services.

### 2.2 Staff Satisfaction Loop

In Figure 3, B3 loop decreases the ratio of resources to demand as the level of patient demand for services decreases, resulting in decreased patient access to resources. By reducing patient access to resources, there is less revenue for the hospital and lower profitability. By reducing profitability, employees' salaries and

benefits are reduced, leading to a decrease in employee motivation that results in a decrease in employee satisfaction. The lower the staff satisfaction, the slower the response to patients' needs, which results in lower patient satisfaction and increased patient complaints, resulting in lower patient demand for hospital services.

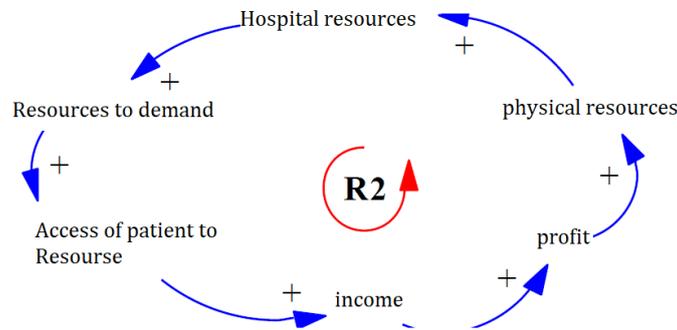


**Figure 3.** Staff Satisfaction Ring in the hospital services.

### 2.3 Benefit loop

In Figure 4, in the R2 loop, to increase physical resources, hospital resources increase, and so does the ratio of resources to patient demand, which increases patient access to resources. As the

patient has access to more resources, the resulting revenue will increase and lead to profitability, and physical resources will also increase.

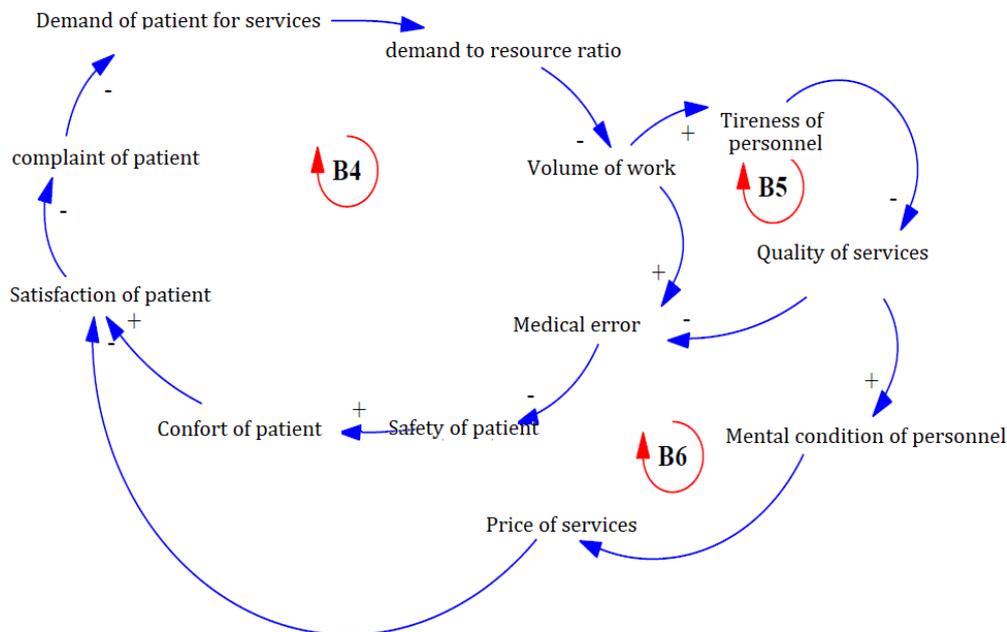


**Figure 4.** Profit loop in the hospital.

### 2.4 Medical Error Rings

In Figure 5, medical error Rings, B4, and B5 rings, with the increase in patient demand for services the ratio of resources to demand reduced, resulting in increased workloads and increased staff fatigue leads to reduced quality of service and increased medical error that affects and reduces patient

safety. With decreasing patient safety, patient welfare and wellbeing decreased, patient satisfaction decreased, and with decreased patient satisfaction, patients' complaints increased, and patients' demand for hospital services decreased (30-32).



**Figure 5:** Medical error rings in the hospital.

### 3. Conclusion

This paper examines the sustainability of the hospital supply chain using social indicators of patient and staff satisfaction and the B / C economic index. Patient and staff satisfaction indices and profit-to-cost ratios are factors of sustainability in the hospital supply chain. Given the increasing demand and limited resources,

decisions must be made based on the sustainability of the hospital's supply chain concerning the current situation and considering the future status of the three sustainability dimensions (1, 4, 6-8, 33). This paper uses system dynamics to help sustain the hospital supply chain. The cause and effect model shows the relationship between factors associated with patient and staff

satisfaction indices and the benefit-cost ratio. The next stage of this research is to complete the model with variables based on environmental and economic dimensions of sustainability and their relationship with the social dimension. After completing the model, validation of the cause and effect model is performed. The purpose of model validation is to ensure that variables and their relationships are rational. For validation, the questionnaire uses the opinions of experts in hospitals, patients, and suppliers, to improve and validate the model and the variables mentioned therein. The final cause-and-effect model and the flow model will be created after applying their views. Then, a system dynamics model simulation is created based on the model and the information obtained to help decision-makers understand the variables and the relationships between them.

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