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Research Article

A Dynamics Approach for Maturity Assessment of Hospital Supply Chain Management

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Abstract

Maturity assessments are conducted for the continuous improvement of hospitals. These assessments are valuable tools for diagnosing in hospital supply chain management (HSCM) processes and implementing targeted solutions to improve overall performance and address challenges effectively and efficiently. Customer satisfaction, inventory management, technology, and collaboration are the main problems that need to be addressed in hospitals. This study aimed to better understand several variables in maturity assessments, such as people, processes, technology, and partners in the management of hospital supply chains. HSCM focuses on reducing hospital costs while improving hospital services. This qualitative study applied a content analysis of data collected in semi-structured interviews. The variables were modeled in causal loop diagrams to present the interrelationships between decision factors. The findings revealed 27 decision factors. Four dominant factors influenced the maturity assessment of HSCM: the number of people in the training area; the number of patients in the process area; supply chain integration in the technology area; and inventory management in the partner area.

Keywords: system dynamics, hospital supply chain management, partnerships, supply chain integration, maturity assessment

1. Introduction

Hospitals are complex systems that aim to provide the best services to patients. These systems are characterized by interconnectedness, interdependence, and dynamic complexity. Hospital systems are committed to providing high-quality health services and ensuring operational continuity and financial sustainability. Supply chain management (SCM) has a significant positive effect on achieving these goals (Moons et al. (2019))Hospital supply chain management (HSCM) focuses on reducing hospital costs while improving hospital services (Setiawati et al. (2022)"<Hospital Supply Chain Management Issue, Method, and Technology.pdf>"). HSCM is concerned with the entire system in the hospital, including drugs, medical devices, and patients who may or may not have experience in the hospital treatment process. In addition, technology aids in the integration of the entire process.

In the context of hospitals, maturity assessments typically involve evaluating the hospital's readiness, effectiveness, and efficiency in various domains, such as clinical care, patient safety, operational processes, information technology, human resources, financial management, and regulatory compliance. Maturity assessment models often use maturity levels (e.g., initial, repeatable, defined, managed, and optimized) to categorize an organization's maturity and to provide a roadmap for continuous improvement (Paulk et al. (1993)). Based on previous research (Mettler (2011); Setiawati et al. (2022)), maturity assessments in HSCM can be enhanced in three areas: people, processes, technology, and partnerships. These are integral components of maturity assessments in HSCM because they collectively shape the capabilities, performance, and resilience of the healthcare supply chain. By addressing these areas comprehensively, hospitals can optimize their supply chain operations, enhance patient care, and achieve strategic objectives related to cost containment, quality improvement, and organizational excellence (Kumar and Kumar (2014)).

Regarding the people aspect, the healthcare landscape has undergone a remarkable metamorphosis driven by a growing emphasis on competitiveness, financial sustainability, and the imperative to meet and exceed customer expectations (Fang et al. (2019)). Customer satisfaction has become an issue for hospitals (Alqudah et al. (2022)). In relation to process, inventory management in hospitals is faced with increasingly complex challenges, including increased demands, changing regulations, and the need for advanced technologies. It is important to identify best practices, innovative solutions, and efficient approaches in hospital inventory management (Beliën and Forcé (2012)).
Regarding technology, the complexity of hospital supply chains makes it difficult to implement and use information technology (IT) to enhance inventory control and the entire system (Nachtmann and Pohl, 2009). The lack of data

standards, inadequate visibility, and the poor quality of available information are significant IT system challenges in healthcare supply chains, according to 42% of the 1,381 healthcare supply chain professionals who responded to the Center for Innovation in Healthcare Logistics healthcare supply chain survey (Nachtmann and Pohl, 2009). In hospital partnerships, the challenges include collaborations between hospitals and suppliers and between hospitals and the government (Setiawati et al. (2023)).

Maturity assessments are a valuable tool for hospitals to diagnose problems within their SCM processes and implement targeted solutions to improve overall performance and address challenges effectively, specifically in the areas of people, processes, technology, and partnerships. Research on this topic is important because by knowing the dominant factors of maturity assessments, hospitals can identify areas that need improvement and develop strategies to increase their efficiency, quality of service, and overall competitiveness. This study used a qualitative method that combined case studies of hospitals in Indonesia, semi-structured interviews, content analysis, and causal loop diagrams. The total number of respondents used, based on Yin's theory, is until the interview results reach maturity.

Bohme et al. (2014)) stated that using systems thinking, such as in a causal loop diagram (CLD), can be applied to identify effective interventions and potentially transferable best practices in healthcare. Mirghafoori et al. (2018) concluded that through information management, supplier relationship management, service management, and customer relationship management, hospital performance can be improved. Thus, this study aimed to comprehend causal relationships and subsequently identify the potential for system improvement from a critical and realistic perspective. The results were modeled using a CLD.

In the following sections, we first present the literature review, followed by the methodology used in the study. The results are described and discussed in Section 4, including their implications for hospital management. Finally, we discuss the limitations of this study and recommend future directions for extending this research.

2. Literature Review

The hospital supply chain management literature spans the domains of people, process, technology, and partnership. In this section, we first review the literature on these domains in the context of hospital supply chains. We then provide a table that summarizes the relevant supply chain literature for each domain.

2.1 People in Hospital Supply Chain Management

To improve supply chain performance in hospitals, positive patient experience is vital. According to Ozcelik et al. (2021), five main actors influence the patient's hospital experience: the provider (i.e., the image of the hospital); the patient (i.e., positive experience); the physician; the personnel (i.e., human resources department); and the setting (location). Based on the top 10 global health supply chain issues (Privett and Gonsalvez (2014)), high workloads, lack of training, inadequate facilities, poor working conditions, and inadequate salaries affect not only employees' ability to do their jobs but also their morale and turnover. Rohleder et al. (2010) found that problems in treating patients, such as waiting time and congestion in the clinic, led to patient dissatisfaction and staff morale issues. By using the model, Rohleder et al. (2010) identified improvement alternatives, including optimized staffing levels, better patient scheduling, and prompt staff arrival. Al-Saa'da et al. (2013) found significant effects of supply chain management dimensions, such as relationships with suppliers, specifications, standards, deliveries, and after-sales service, on the quality of health services. However, previous results also indicated no differences between supply chain management and the quality of health services based on the gender, qualification, age, or experience of staff and physicians. Young et al. (2016), Jena and Ghadge (2021), Brown et al. (2014) concluded that there is a relationship between the hospital's employment of physicians and supply chain performance. In SCM, human resources have a positive impact on supply chain performance. Rungsrisawat et al. (2019) showed that efficient and skilled human capital can contribute to improving supply chain performance. Quality human capital can help meet patient demands and increase operational efficiency in the health supply chain. Khademi et al. (2020) examined the factors that influence hospital supply chain resilience, finding that the main factors consisted of staff attendance, suitability, infrastructure safety, disaster management, support, and capacity systems. Setiawati et al. (2023) found that people's maturity was an important factor in their ability to develop staff skills. Based on the literature review, the variables regarding people in HSCM are shown in Table 1.

Table 1

2.2 Process in Hospital Supply Chain Management

According to the supply chain operation reference (SCOR) model, processes in HSCM consist of the following: scheduling as the planning process; procurement as the sourcing process; inventory as the making process in a service industry; and delivery. Kumar et al. (2008) study on the procurement process in hospitals showed that balanced scorecards can enhance the assessment process. Kumar and Kumar (2014) showed that, by using modeling, many patients were not served because of the huge stockout in state governmental rural healthcare systems. Handayani et al. (2017) found that the main dimensions of the HSCM process were responsiveness and reliability in achieving optimal healthcare service quality performance. Moons et al. (2019) measured the logistic performance of internal

HSCM, finding that the variables that improved performance were transportation cost, resources, capacity restriction, and the layout of the hospital. Liao et al. (2011) showed that logistics systems in hospitals differ from the manufacturing supply chain, particularly agility in the relationship between the hospital and the pharmaceutical company (i.e., delivery). Kamran et al. (2023) showed that distribution cost was a significant variable in minimizing supply chain costs. Setiawati et al. (2023) identified the significance of HSCM in monitoring processes and key performance indicators in hospitals. Gonul Kochan et al. (2018) focused on healthcare product demand and supply mismatches caused by poor demand and inventory visibility, which can have catastrophic effects on both the economy and patient care. Based on the literature review, the variables in the process of HSCM are shown in Table 2.

Table 2

2.3 Technology in Hospital Supply Chain Management

Technology in HSCM consists of the hospital information system (HIS), decision support system (DSS), vendor-managed inventory (VMI), and IT outsourcing. Kochan Gonul Kochan et al. (2018) showed that cloud computing can enable electronic supply chain management (e-SCM) in HSCM. The higher the visibility of supply chain management, the higher the hospital responsiveness, and the lower the inventory cost, supply cost, and supply shortage. Bag et al. (2023) concluded that the higher the involvement of managerial factors, the higher the technology development. Wagrell et al. (2022) showed that healthcare integration can enhance sustainability factors in hospitals. Govindan et al. (2020) found that technology can manage demand specifically during periods of chaos, such as the Covid-19 situation.

El Mokrini and Aouam (2022) research focused on decision support systems for policymakers in hospitals. The findings indicate that governments should assess the outsourcing risk of technology used in hospitals. The four strategies are transportation outsourcing, warehouse outsourcing, product logistic outsourcing, and regional outsourcing. Transportation costs affect cost efficiency, while warehouse outsourcing has a lower effect on cost efficiency compared with other strategies. atopoulos Matopoulos and Michailidou (2013) findings showed that the implementation of vendor-managed inventory (VMI) in Greek hospitals can enhance financial benefits through inventory efficiency. Tortorella et al. (2021) found that enhancing interactions in hospitals is an important aspect of digital healthcare applications. Lee (2017) findings indicated that in smaller hospitals, IT sourcing created more value than in-house IT. Cloud-based technology can increase both demand and inventory visibility in the hospital supply chain, increase hospital responsiveness, and decrease inventory costs (Gonul Kochan et al. (2018)). Based on the literature review, the variables related to technology in HSCM are shown in Table 3.

Table 3

2.4 Partnerships in Hospital Supply Chain Management

Partners in hospital supply chain management include suppliers and governmental decision makers (Setiawati et al. (2023)). Khosravi et al. (2019) found that two types of partnerships are an internal supply chain and an external supply chain. Internal supply chains involve suppliers, employees, patients, and patients' relatives, while external supply chains consist of the government or decision makers and the remaining stakeholders. Kwon et al. (2016) showed that supplier relationship management can enhance the value added for both hospitals and suppliers. It can decrease waste, total cost of ownership, lead time, and inventory, and increase flexibility, speed to patient, and innovation. Spieske et al. (2022) study applied resource dependence theory, which consists of bridging and buffering strategies. Bridging theory considers information and resource sourcing, joint planning and decision making, long-term/strategic-supplier partnerships, purchasing alliances, coopetition, supply network visibility, and supplier capacity visibility. The buffering strategy consists of multiple sourcing and vertical integration. Spieske et al. (2022) concluded that complementing bridging with buffering would increase risk mitigation in hospital supply chain management. Abdallah et al. (2017) researched the relationships between trust in suppliers in hospital–supplier integration and hospital supply chain performance. Their findings showed that trust had a positive significant effect on suppliers, hospital–supplier management, and hospital performance. Alshahrani et al. (2018) concluded that hospital–supplier integration has a positive impact on overall hospital performance in developed countries. Mandal (2017) examined the dynamic capabilities of hospitals, including the visibility of sensing, learning, integration, and coordinating. They concluded that hospital dynamic capabilities positively influence hospital–supplier collaboration. Azzi et al. (2013) showed that outsourcing and collaborating between actors yielded the highest economic value and cost effectiveness. Bian et al. (2021) concluded that by decentralizing the supply chain, a 3PL provider would have a positive effect on hospital supply chain management. Their findings showed that the business model with 3PLs outperformed the traditional model.

Bian et al. (2021) found that, when the Chinese government was involved in hospital regulation, there was an increase in health facilities and health personnel in hospitals over time. They concluded that collaboration among stakeholders is vital for performance improvement in hospitals. Based on the literature review, the variables related to partnerships in hospital supply chain management are shown in Table 4.

Table 4

3. Methods

In this study, the research methods included a review of the extant literature related to maturity assessments in HSCM, which includes people, processes, technology, and partnerships, followed by semi-structured interviews with stakeholders. A content analysis of the collected qualitative data was applied to the interview transcripts. Causal loop diagrams were then developed to understand the interrelationships between stakeholders and factors. Fig. 1 illustrates the research methodology framework adopted in this study.

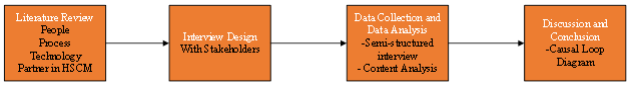

Fig. 1. Methodology Framework

3.1 Interview Design

A total of 22 questions (Table 5) covering the topic of interest were developed, which varied slightly depending on the informants' roles.

Table 5

3.2 Data Collection Method

To examine how the people, processes, technology, and partnerships in hospitals, semi-structured interviews were conducted to determine the perspectives of multi-stakeholders, which were characterized by plurality and subjective interpretations of the four types of hospitals in Indonesia: A, B, C, and D. These types are differentiated based on the level of facilities and the following four accreditation assessments: paripurna, madya, utama, and dasar. It consists of project owners, employees in hospitals (e.g., procurement and pharmacy), HSCM professionals, academic experts, and practitioners in hospitals. They were selected as respondents because they had experience related to HSCM. Semi-structured interviews were conducted with 10 stakeholders from six different institutions from October 2022 to December 2022. Snowball sampling was adopted to determine the most influential stakeholders (Table 6).

Table 6

3.3 Data Analysis

This study aimed to investigate systemic factors that influence hospital supply chain management regarding people, processes, technology, and partnerships to accelerate maturity transformation. A content analysis was applied to examine the system dynamics. A content analysis of the interview transcripts was conducted using the qualitative data analysis software ATLAS.ti. Content analysis is used in grounded theory studies conducted in multiple iterative processes. The first dimension group is the element of the maturity system. The second dimension group is related to factors that dynamically interact in the mature system (i.e., people, processes, technology, and partnerships). The system dynamics approach is used to analyze nonlinear behavior or patterns of complex systems; in other words, it is the basis of systemic thinking. In a study on the relationships between interconnected complex systems and policy interventions, Sterman (2000) highlighted the complexity of making effective and sustainable policies. His approach underscores the importance of comprehensively understanding system dynamics and avoiding the unforeseen effects of policy interventions. A rich understanding of the system underlying a policy problem can be developed by modeling feedback loops and analyzing the system's behavior over time.

When a system is characterized by nonlinear behavior, system dynamics are widely used in policy analysis. An advantage of system dynamics modeling is that it addresses stakeholders' limited rationality, which restricts the causal maps of its systems. As a result, it is possible to solve the issue of the stakeholders' limited awareness of the systems because of the variety of roles they play. To comprehend the causative relationship and subsequently identify the chance for system improvement from a critically realistic perspective, a causal loop diagram, or CLD, was used in this study. Stakeholders can utilize the systems model to assist learning by simulating the critical elements of people, process, technology, and partnership in hospital supply chain management.

4. Results and Discussion

In the healthcare industry, hospitals are complex systems that aim to provide the best services to patients. Interconnectedness, interdependence, and a dynamic nature characterize these complex systems. The aim of hospital systems is to provide high-quality health services and ensure operational continuity and financial sustainability.

4.1 Interview Results

The results of the data collected in the semi-structured interviews in the people area revealed the knowledge and capabilities of the staff and physicians. The effective management of the supply chain in hospitals plays a pivotal role in ensuring seamless operation and quality patient care. The HSCM professionals and academic experts who participated in this study agreed that several key factors contributed to this, including the number of training programs available to staff and physicians, which directly affected the level of competence among healthcare professionals. Moreover, employees in the pharmacy area shared that patient demand, combined with hospital accreditation standards, underscored the need for an optimal number of physicians and staff, as well as well-equipped facilities, to meet service requirements and maintain accreditation status. The project owner stated that prioritizing customer satisfaction and managing medical

charges appropriately are essential for sustaining patient trust and financial viability. Additionally, healthcare workers in the pharmacy and procurement areas risk burnout. Therefore, implementing incentives and support systems is crucial in fostering a healthy work environment and sustaining workforce efficiency. This finding differs from the literature review; the interviewees did not include efficiency, such as waiting time, hospital income, clinical time, and salary expenses, and they did not mention the relationships between people, service quality, and patient safety.

Regarding the process area, the results focused on the SCOR model, which consists of scheduling, procurement, inventory, and delivery. Academic experts offered that in hospital supply chain management, it is critical to optimize processes to meet patient demands efficiently and minimize costs. This involves meticulous management of purchasing, inventory, and transportation costs to ensure the timely availability of medical supplies and equipment. The project owner concluded that by accurately forecasting patient demand, hospitals could streamline procurement processes, reduce purchasing costs, and minimize the risk of stockouts or overstocking. The results showed that HSCM professionals focused on effective inventory management strategies, which help mitigate inventory holding costs by maintaining optimal stock levels. Streamlining transportation logistics further contributes to reducing supply chain costs by minimizing transit times and optimizing delivery routes. Through these efforts, the procurement and pharmacy employees emphasized that hospitals can enhance operational efficiency, improve patient care outcomes, and achieve cost savings across the supply chain. The literature reviewed in this study discusses related key performance indicators (KPIs), such as length of waiting list, workload, operation time, requisition completion rate, and other important KPIs. However, in the present study, the interviewees focused on the process of determining the number of patients and supply chain costs.

Technology plays a pivotal role in enhancing the management of hospital supply chains, focusing on supply chain integration and inventory visibility. Through sophisticated IT systems, hospitals can achieve seamless integration of various supply chain processes, allowing for real-time data sharing among stakeholders. In this study, the academic experts stated that integration enhances inventory visibility, enabling healthcare providers to track stock levels accurately and anticipate demand fluctuations. Additionally, the employees in procurement and pharmacies said that technology helps reduce lead times by automating procurement processes and optimizing supply chain workflows. However, implementing and maintaining such technology requires significant IT labor and capital investment. The project owner suggested that hospitals need to decide whether to allocate resources for in-house IT infrastructure development or outsource IT capital to specialized service providers. Striking a balance between in-house capabilities and outsourcing can ensure the effective utilization of technology in hospital supply chain management while optimizing costs and operational efficiency. The respondents focused on lead time and inventory visibility, while the literature reviewed in this study focused on variables related to profit and cost.

The academic experts interviewed in this study expressed that partnerships and collaborations play a crucial role in optimizing inventory management within hospital supply chains and fostering trust among stakeholders while navigating the complexities of regulations and vendor relationships. By forging strategic partnerships with reliable vendors, hospitals can streamline procurement processes, thus reducing the number of vendors while ensuring a stable supply of essential medical supplies and equipment. Moreover, the interviewees in the procurement and pharmacy areas stated that collaboration facilitates improved inventory visibility, allowing for better tracking of stock levels and minimizing lead times. Additionally, partnerships help hospitals remain compliant with the regulations governing the healthcare industry, as collaborative efforts often entail shared knowledge and resources for regulatory adherence. Overall, fostering partnerships in hospital supply chain management enhances operational efficiency, promotes trust among stakeholders, and facilitates compliance with regulatory requirements. Hospital supply chain management performance and data protection should be considered in collaborations and partnerships.

Based on the results of the interviews, the decision factors from the open coding and dimensional determination are shown in Table 7. The researchers referred to Table 1-4 in the literature review and identified new and emerging dimensions. The 63 factors consisted of 16 factors regarding people, 23 factors regarding process, 16 factors regarding technology, and eight factors regarding partnerships. The results of the analysis of the interview data showed that 27 of 63 factors influenced the maturity system in hospital supply chain management implementation. These 27 factors (brown color in Table 7) comprised 10 in people, five in process, six in technology, and six in partnerships. The 27 factors selected were the result of semi-structured interviews. The sentences were conveyed directly or indirectly by the interviewees. The code occurrences (0,1,2,..) referred to how frequently each factor was mentioned by the interviewee, which was then interpreted as the perceived importance of the factors. These occurrences served as a quantitative measure in the qualitative analysis of each factor. The identified factors were categorized into four decision categories, as follows.

Table 7

4.2 Causal loop diagram (CLD)

The causal loop diagram (Fig. 2) shows interrelationships among decision factors: arrow directions represent causal relationships, and a change in direction is denoted by a plus or minus sign attached to each arrow to show the polarity of the feedback loops. The analysis of the reinforcing and balancing roles of each factor identified four driving grouping loops: people, process, technology, and partnerships. The different colors of the arrows and variables represent the decision factors in each of the four driving grouping loops. The red arrow represents people loops, the blue arrow represents process loops, the purple arrow represents technology loops, and the orange arrow represents partner loops. However, because each driving grouping loop does not operate in isolation, it is interrelated with each factor on various levels. Table 8 shows the details in causal Figures 3 to 6.

Figure 3, people's driver, shows that the number of training programs directly influences the level of physician and staff competence; as training increases, competence levels rise. This relationship is reinforcing because competent personnel attract more patients, subsequently increasing the demand for services. Conversely, the number of physicians and staff impacts patient demand, creating a balancing loop; an excess of staff may lead to a decrease in patient demand due to perceived inefficiency. Furthermore, patient demand affects facility requirements, with higher demand necessitating more facilities. This relationship is reinforcing, as adequate facilities enhance hospital accreditation, which in turn boosts customer satisfaction. However, an increased risk of burnout among staff negatively impacts customer satisfaction, creating a balancing loop. Moreover, the relationship between medical charges and incentives influences the risk of burnout, where higher charges may lead to increased incentives but also higher stress levels among staff, thus affecting patient demand.

The process driver is shown in Figure 4. The number of patient demands affects transportation costs because an increase in demand necessitates increased and extensive transportation, which leads to higher costs. This relationship formed a reinforcing loop: As patient demand rises, transportation costs escalate, which subsequently impacts supply chain costs. Furthermore, patient demand influences purchasing costs and subsequently affects supply chain costs and inventory expenses. This creates a reinforcing loop in which increased demand leads to higher purchasing and supply chain costs, which in turn elevates inventory expenses. Conversely, supply chain costs impact supply chain integration; higher costs may incentivize healthcare facilities to invest in integrating their supply chains for efficiency, forming a reinforcing loop. However, a balancing loop exists between supply chain integration and supply chain costs; as integration increases, costs initially rise but eventually stabilize or decrease as integration streamlines processes and reduces inefficiencies.

The technology driver is shown in Figure 5. Inventory visibility directly influences inventory costs; greater visibility allows for better control over inventory levels, thus reducing costs. This relationship forms a reinforcing loop: As visibility increases, costs decrease, leading to improved visibility and further cost reductions. Additionally, IT capital outsourcing impacts supply chain integration, which then influences inventory visibility and lead time. This creates a reinforcing loop in which outsourcing IT capital enhances integration, subsequently improving visibility and reducing lead time. Similarly, IT labor contributes to supply chain integration, forming another reinforcing loop in which the availability of skilled IT personnel enhances integration efforts. Conversely, a balancing loop exists between in-house IT capital and supply chain integration. Although in-house IT capital may initially increase integration efforts, excessive investment can lead to diminishing returns, thus necessitating a balance between in-house resources and integration needs.

The partnership driver is shown in Figure 6. Inventory visibility is linked to inventory management. Greater visibility facilitates better management practices, leading to efficient inventory levels. This forms a reinforcing loop: Improved visibility enhances management, resulting in further improvements in visibility and management. Moreover, the number of vendors impacts trust. As the number of vendors increases, trust may diminish because of potential complexities in managing relationships. Conversely, trust influences the number of regulations; higher levels of trust may lead to fewer regulations, as there is mutual understanding and reliability between parties. However, regulations also influence the number of vendors and, subsequently, trust, creating a balancing loop. An increase in regulations may lead to a reduction in vendors, but it could also enhance trust among the remaining vendors.

Overall, the results indicate that regarding maturity assessment in hospital supply chain management, people, processes, technology, and partnerships can be enhanced through interrelated factors (Figures 3–6).

Fig .2. Causal Loop Diagram
Fig .3. People's driver
Fig .4. Process's driver
Fig .5. Technology's driver
Fig .6. Partner's driver
Table 8

5. Conclusion

This study systematically modeled the structure, function, and process of the hospital supply chain management system for maturity assessment. The study identified 27 decision factors categorized into four dimensions: people, process, technology, and partnerships. Among these 27 factors, the amount of training and the number of patient demands, supply chain integration, and inventory management were the four most influential factors mentioned by all the stakeholders in the interview process. Optimal maturity assessments can be achieved by focusing on these four factors. The CLD showed reinforcing and balancing relationships that enhanced the maturity assessment. Our findings suggest that hospitals should focus on improving employee engagement to improve hospital maturity. This could be achieved by implementing strategies such as employee recognition programs, performance-based pay, and opportunities for professional development. Regarding technology, implementing changes needed to improve hospital maturity can be challenging. Hospitals may face financial constraints, logistical challenges, and employee resistance. Managers should carefully consider these challenges in developing and implementing strategies for improvement.

6. Limitation and Further Research

This study has several limitations. First, verified empirical data were not used in the study. Instead, causal loops were developed to capture the relationships among the variables. In future research, empirical data could be collected to validate the study's findings and contribute significant results for further investigation. Second, the generalizability of the results is restricted to the hospital supply chain context. Because this study focused only on West Java, Indonesia, future research could be based on a greater number of experts from each region to improve the generalizability of the results.

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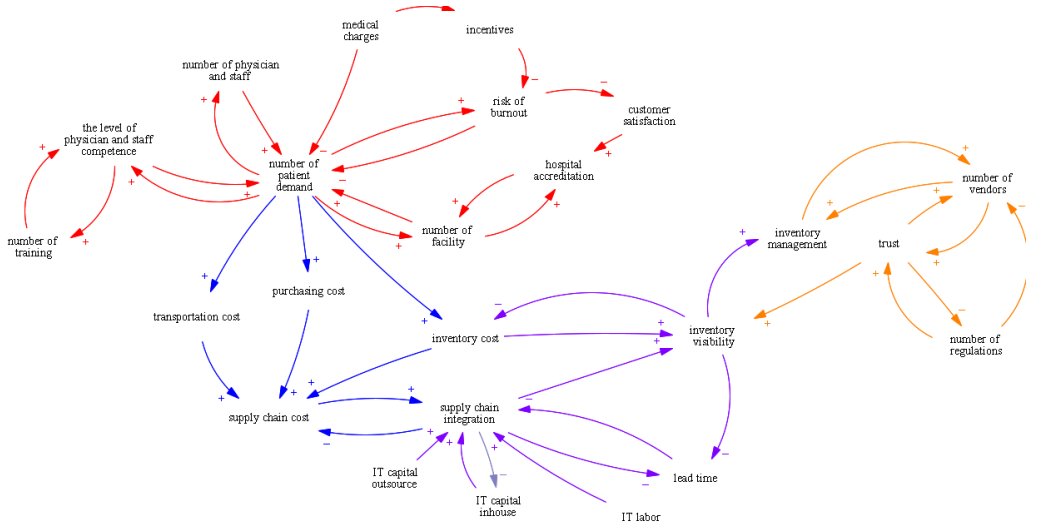

Fig .2. Causal Loop Diagram

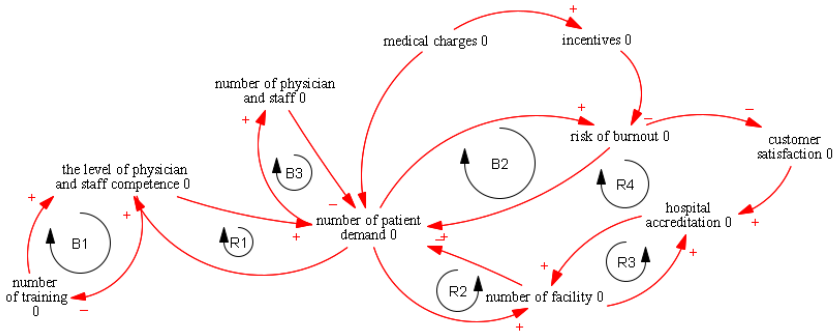

Fig .3. People's driver

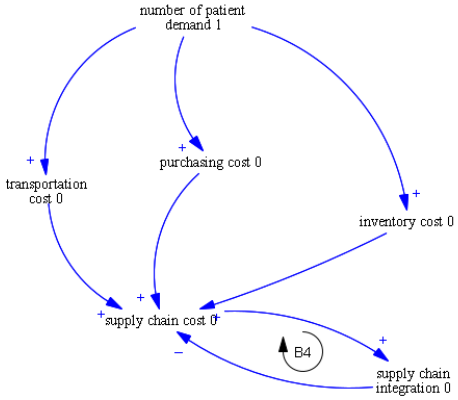

Fig .4. Process's driver

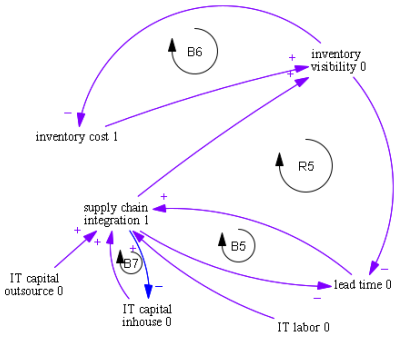

Fig .5. Technology's driver

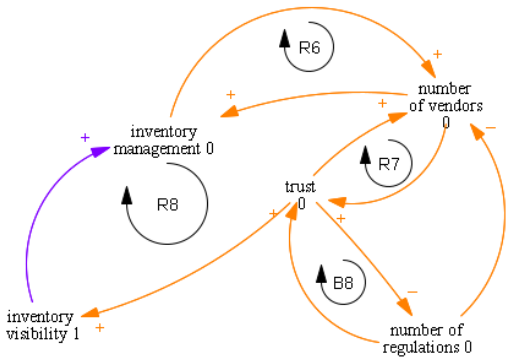

Fig .6. Partner's driver

Table 1 People in Hospital Supply Chain Management

Actors	Variables	Definition	References
Patient	Customer satisfaction	The satisfaction of the patient in receiving services from the hospital	Fang et al. (2019)

Table 1 People in Hospital Supply Chain Management

Actors	Variables	Definition	References
Physicians (including doctor, nurse, pharmacist)	medical charges	The cost incurred by patients for seeking treatment at the hospital	Fang et al. (2019)
	service quality	The speed of handle patients	Syah and Wijoyo (2021) and Khademi et al., 2020
	number of patient visits	The number of patients who come to the hospital	Syah and Wijoyo (2021)
	waiting time	The amount of time patients wait before being attended to by the doctor	Chen et al. (2017)
	hospital income	The received by the hospital from patient treatment outcomes	Badia et al. (2017)
	clinical time	The time that the doctor spends in treating patient	Drossman and Ruddy (2020)
	risk of burnout	The level of satisfaction of the doctor in handling patient	Drossman and Ruddy (2020)
	patient safety	The Level of trust that the patients have in doctor that makes patient feel safe	Drossman and Ruddy (2020)
Human resource department	Incentives	The amount of money the hospital allocated to its physicians and staff for attending training	Drossman and Ruddy (2020)
	Salary expenses	Salaries given to doctors and hospital staff	Abdulsalam et al., 2018 and Stock et al., 2023
	Hospital accreditation	The level of assessment or rating of the hospital	Goyal and Kaur (2023)
	number of trainings	Training given to staff at the hospital	Setiawati et al. (2023)
	number of facilities	The facilities provided by the hospital to the patients	Yousefli et al. (2017)
	number of physicians & staff	The number of doctors and staff in the hospital	Rungsrisawat & Jermsittiparsert, 2019
	the level of staff and physicians' competence	The level of competence staff and doctor in treating patients	Khademi et al., 2020

Table 2 Process in Hospital Supply Chain Management

Process	Variables	Definition	References
Scheduling	Length of waiting list	Number of people or entities waiting to receive hospital services	Lapierre and Ruiz (2007)
	Workload	The amount of work or tasks that must be done in a certain period of time	Lapierre and Ruiz (2007)
	Operation time	Time taken to execute a business process from start to finish	Lapierre and Ruiz (2007)
Procurement	Requisition completion rate	Number of internal request forms completed out of all requests received	Kumar et al. (2008)
	GPO participation rate	Number of rates ordered by GPO out of all total items	Kumar et al. (2008)
	Effectiveness of processing time	Actual average cycle time of targeted average cycle time	Kumar et al. (2008)
	Supply chain cost	Total departmental expenditure out of total purchase value	Kumar et al. (2008)
	Stock take discrepancy	Difference between actual stock quantity and that recorded in the inventory management system	Kumar et al. (2008)

Table 2 Process in Hospital Supply Chain Management

Process	Variables	Definition	References
	Returns processing costs	Return of drugs from treatment units to the hospital pharmacy department for expired or unused drugs	Ibn El Farouk et al. 2013
Inventory	Inventory	Inventory of goods held by the hospital to meet patient demand and ensure smooth operations.	Ibn El Farouk et al. 2013
	Inventory turnover	How quickly inventory is sold and replaced	Ibn El Farouk et al. 2013
	Days of supply	Number of days that inventory levels can sustain sales	Ibn El Farouk et al. 2013
	Safety stock	Amount of additional inventory to address uncertainties in supply or demand	Liao et al. 2011
	Fulfillment rate	The hospital's patient demand fulfillment rate	Gonul Kochan et al. (2018)
	Carrying cost	Cost of holding inventory, including storage, insurance medical devices, buildings, employees, etc.	Ibn El Farouk et al. 2013
	Patients demand	Number of drugs needed by patient	Cigdem Gonul Kochan et al. 2017
	Profit	Revenue - Expenses	Kwon et al. (2016)
	Ordering cost	Costs associated with the ordering process and managing orders for goods or services.	Moons et al. (2019)
	Purchasing cost	Costs directly related to the acquisition of goods or services from suppliers	Moons et al. (2019)
Delivery	Lead Time	Starting from production time, ordering time from manufacturers and delivery time	Liao et al 2011
	Transportation cost	Transportation costs from manufacturing to hospital	Kamran et al. (2023)
	Transportation capacity	Vehicle's capacity in delivery	Liao et al 2010
	Replenishment medicine	Procurement / replenishment of drugs used in patient care	Ibn El Farouk et al. 2013

Table 3. Technology in Hospital Supply Chain Management

Technology	Variables	Definition	References
Performance metrics of HIS	average inventory level	(beginning inventory + ending inventory)/2	Gonul Kochan et al. (2018)
	lead time	the total time it takes for an order to be fulfilled, from the moment the order is placed until the product is delivered to the customer	Gonul Kochan et al. (2018)
	unfilled order	the requested products or services are currently not available in inventory or are not ready for delivery, so the order remains open until the items can be supplied.	Gonul Kochan et al. (2018)
	inventory visibility	the ability of a business to track, monitor, and manage the real-time status and location of its inventory throughout the supply chain.	Gonul Kochan et al. (2018)
	customer service level	(number of orders fulfilled on time/Total number of customer orders) *100%	Gonul Kochan et al. (2018)
Decision Support System (DSS)	Perceived risk	the subjective assessment or judgment that individuals make about the potential uncertainties, dangers, or negative outcomes associated with a particular decision, action, or situation	El Mokrini and Aouam (2022)
	Total cost of Supply Chain	the sum of all costs incurred by a company in the process of designing, producing, storing, transporting, and delivering a product or service to customers	El Mokrini and Aouam (2022)
Vendor Managed Inventory (VMI)	product portfolio range	the variety and diversity of products or services offered by a company within its overall product portfolio	Matopoulos and Michailidou (2013)
	cost contribution	the portion of total costs that can be attributed to a specific product, product line, customer, market segment, or any other identifiable component within a business.	Matopoulos and Michailidou (2013)
	delivery frequency	how often essential supplies, medications, equipment, or other necessary items are delivered to the facility.	Matopoulos and Michailidou (2013)
	size of supplier base	the number of individual suppliers or vendors that a hospital engages with to source various goods and services	Matopoulos and Michailidou (2013)
	inventory management	the systematic control and oversight of medical products, equipment, and supplies that are essential for patient care and hospital operations	Matopoulos and Michailidou (2013)
Outsourcing of IT	profit	Revenue - expenses	Lee (2017)
	IT labor	the workforce within the Information Technology (IT) industry that is engaged in tasks related to the planning, development, implementation, maintenance, and support of information systems,	Lee (2017)

Table 3. Technology in Hospital Supply Chain Management

Technology	Variables	Definition	References
		software applications, hardware infrastructure, and other technology-related functions.	
	IT capital inhouse	the information technology (IT) assets, resources, and capabilities that are owned, managed, and operated internally within an organization rather than being outsourced to external service providers	Lee (2017)
	IT capital outsource	the practice of outsourcing certain aspects of an organization's information technology (IT) needs to external service providers rather than managing them in-house	Lee (2017)

Table 5 Interview Questions

Categories	**Questions**	**References**
Issues	Confirm the problems that exist in the Hospital.	Alqudah et al. (2022)
	How is the development of hospital issues today?	
	What are the policies related to this issue?	
People	How to choose staff in a hospital? What are the conditions?	Setiawati et al. (2023) Goyal and Kaur (2023)
	Were there any problems choosing these people?	
	Have the skills of the people recruited met expectations?	
	Is there training for these personnel? If so what and how?	
	What is the reason for holding training for staff at the hospital?	
	What are the policies related to training in hospitals?	
Process	What are the processes in the Hospital?	Kwon et al. (2016) Matopoulos and Michailidou (2013)
	Is there any monitoring process?	
	What is the process of monitoring and measuring as well as procedures at the hospital?	
	Are there KPIs and measured? managed?	
	What are the policies related to the monitoring process in hospitals?	
Technology	Why do hospitals use technology?	Mettler (2011) Setiawati et al. (2023)
	What are the internal and external policies regarding technology?	
	What are the obstacles to using technology in hospitals?	
	What technology systems are there in the Hospitals that you have managed?	
Partner	Who are the close partner and other partner from this hospital?	Abdallah et al. (2017)
	How to have a good relationship with both close partner and distant partner?	
	What are the internal and external policies regarding partner?	
	What is the partnership relationship with the hospitals that you have or are currently managing?	

Table 6 Informant Lists

No	Data Respondent	Years of Experience	Number of Respondent
1	Project Owner	12	1
2	Employee in Procurement Area	8 & 5	2
3	Employee in Pharmacy Area	10 & 18	2
4	Professional in HSCM	13	1
5	Academic Expert in HSCM	3 & 4	2
6	Practitioners in Hospitals	4 & 5	2
Total			10

Table 7 Decision Factors and Occurrences of Stakeholders

	Factors	Project Owner	Employee in Procurement area	Employment in Pharmacy area	Professional in HSCM	Academic Expert in HSCM	Practitioners in Hospital	Totals
People								
P1	Customer satisfaction	1	0	0	0	0	1	2
P2	medical charges	1	0	0	0	1	0	2
P3	service quality	0	0	0	0	0	0	0
P4	number of patient visits / patient demand	1	0	1	3	2	3	10
P5	waiting time	0	0	0	0	0	0	0
P6	hospital income	0	0	0	0	0	0	0
P7	clinical time	0	0	0	0	0	0	0
P8	risk of burnout	0	1	0	0	0	0	1
P9	patient safety	0	0	0	0	0	0	0
P10	Incentives	0	0	0	0	1	0	1
P11	Salary expenses	0	0	0	0	0	0	0
P12	Hospital accreditation	2	1	2	3	1	1	10
P13	number of trainings	10	1	4	11	4	2	32
P14	number of facilities	1	0	1	1	1	0	4
P15	number of physicians & staff	2	0	3	2	2	1	10
P16	the level of staff and physicians' competence	3	2	3	1	2	1	12
Process								
PR1	Length of waiting list	0	0	0	0	0	0	0
PR2	Workload	0	0	0	0	0	0	0
PR3	Operation time	0	0	0	0	0	0	0
PR4	Requisition completion rate	0	0	0	0	0	0	0
PR5	GPO participation rate	0	0	0	0	0	0	0
PR6	Effectiveness of processing time	0	0	0	0	0	0	0
PR7	Supply chain cost	1	0	0	1	0	0	2
PR8	Stock take discrepancy	0	0	0	0	0	0	0
PR9	Returns processing costs	0	0	0	0	0	0	0
PR10	Inventory cost	1	1	0	1	0	0	3
PR11	Inventory turnover	0	0	0	0	0	0	0
PR12	Days of supply	0	0	0	0	0	0	0
PR13	Safety stock	0	0	0	0	0	0	0
PR14	Fulfilment rate	0	0	0	0	0	0	0
PR15	Carrying cost	0	0	0	0	0	0	0
PR16	Patients demand	1	0	1	3	2	1	8
PR17	Profit	0	0	0	0	0	0	0
PR18	Ordering cost	0	0	0	0	0	0	0
PR19	Purchasing cost	0	1	1	1	1	0	4
PR20	Lead Time	0	0	0	0	0	0	0
PR21	Transportation cost	0	1	0	0	0	0	1
PR22	Transportation capacity	0	0	0	0	0	0	0

Table 7 Decision Factors and Occurrences of Stakeholders

	Factors	Project Owner	Employee in Procurement area	Employment in Pharmacy area	Professional in HSCM	Academic Expert in HSCM	Practitioners in Hospital	Totals
PR23	Replenishment medicine	0	0	0	0	0	0	0
Technology								
T1	average inventory level	0	0	0	0	0	0	0
T2	lead time	0	0	1	0	0	0	1
T3	unfilled order	0	0	0	0	0	0	0
T4	inventory visibility	1	0	1	0	0	0	2
T5	customer service level	0	0	0	0	0	0	0
T6	Perceived risk	0	0	0	0	0	0	0
T7	Total cost of Supply Chain	0	0	0	0	0	0	0
T8	product portfolio range	0	0	0	0	0	0	0
T9	cost contribution	0	0	0	0	0	0	0
T10	delivery frequency	0	0	0	0	0	0	0
T11	size of supplier base	0	0	0	0	0	0	0
T12	supply chain integration	1	1	0	0	1	0	3
T13	profit	0	0	0	0	0	0	0
T14	IT labor	1	0	0	0	0	0	1
T15	IT capital inhouse	1	0	0	0	0	0	1
T16	IT capital outsource	1	0	0	0	0	0	1
Partnership								
Pa1	trust	1	0	1	2	1	0	5
Pa2	inventory management	2	1	2	1	3	0	9
Pa3	hospital supply chain performance	0	0	0	0	0	0	0
Pa4	lead time	0	0	1	0	0	0	1
Pa5	inventory visibility	1	0	1	0	0	0	2
Pa6	data protection	0	0	0	0	0	0	0
Pa7	number of regulations	2	1	2	0	0	0	5
Pa8	number of vendors	0	0	1	0	3	0	4
	Total	35	11	26	30	24	10	136

Table 8 Detailed Causal Relationship

Relationships	Code	Variables	Interpretations
Reinforcing	R1	the level of physician staff and competence - Number of patient demand	An increase in the level of physician staff and competence increases the number of patient demand
	R2	Number of patient demand - number of facilities	An increase in number of patient demand increases number of facilities
	R3	number of facilities - hospital accreditation	An increase in number of facilities increases hospital accreditation status

Table 8 Detailed Causal Relationship

Relationships	Code	Variables	Interpretations
	R4	number of patient demand - risk of burnout - customer satisfaction - hospital accreditation - number facility	an increase in number of patients increases risk of burnout that decreases customer satisfaction and hospital accreditation
	R5	Supply chain integration - inventory visibility - lead time	An increase in supply chain integration increases inventory visibility that decreases lead time
	R6	number of vendors - inventory management	An increase in number of vendors increases inventory management system
	R7	trust - number of vendors	An increase in trust increases number of vendors
	R8	inventory visibility - inventory management - number of vendors - trust	an increase in inventory visibility increases inventory management system that increases trust and number of vendors
Balancing	B1	number of training - the level of physician staff and competence	An increase in number of trainings increases the level of physician staff and competence while an increase level of physician staff and competence decrease number of trainings
	B2	risk of burnout - number of patient demand	An increase in risk of burnout decreases number of number patient demand
	B3	Number of patient demand - number of physician and staff	An increase in number of patient demand increases number of physician and staff while decrease number of patient decrease number of physician due to efficiency
	B4	supply chain integration - supply chain cost	An increase in supply chain integration decreases supply chain cost
	B5	supply chain integration - lead time	An increase in supply chain integration decreases lead time
	B6	inventory cost - inventory visibility	An increase in inventory visibility decreases inventory cost
	B7	supply chain integration - IT capital inhouse	An increase in supply chain integration decreases IT Capital inhouse
	B8	trust - number of regulations	An increase in trust decreases number of regulations

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